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Heterogenous networks and services

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Heterogeneous Networks and Services

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Anders Henten, Associate Professor, CICT, was the main supervisor and Henning Olesen, Associate Professor, CICT, was the co-supervisor for the duration of the project.

Heterogeneous Networks and Services

Summary

This thesis considers the development of the mobile industry from a techno-economic perspective. Theory of disruptive technologies and related theories are examined and further developed. While much of technology change has been analysed on either a technical level or a market level, another plane of analysis that links the technical plane to the market plane is developed here.

The changes in the mobile and wireless industry mean that new technologies are constantly being developed. These new technologies can either be classified as being radical in nature or as an incremental technological change. Incremental technological changes are characterised by small changes that are linked to the previous generation of technology and are seen to be advancements of that technology. Radical technological changes, on the other hand, are characterised by a new innovative technology that is different from the existing generation of technology and presents new technological performance breakthroughs.

It is difficult to predict which radical technologies or innovations will result in a market disruption early on in their life cycles. Based on Clayton Christensen's (Christensen 1997) definition of a disruptive technology, it is one that initially has lower performance than the mainstream technology and is aimed at a different market segment. But as the technology develops, it will also occupy a place in the market of the mainstream technology. A mainstream technology refers to one that has the largest percentage of the market. If mainstream technology firms do not address the disruption, it is likely they will fail and the new disruptive firm will grow in size and importance in the industry.

As we move to 3G (3^{rd} Generation Mobile Services) and beyond 3G, one of the biggest challenges is to bridge network heterogeneity; that is, different types of access networks are inter-connected and interoperable, allowing users seamless roaming between different network types. Technology, business as well as standardisation will play a large role in achieving this. Technological innovation and advancement are the foundations of new products and services. Schumpeter described the motor of development as the innovation itself. However, business and financial aspects must also be considered as they provide the bottom line for firms in the industry. Standardisation is increasingly required due to the number of different technologies in the industry.

The heterogeneity of networks and services cannot be bridged by one company alone; it requires the efforts of many different companies working together. The mobile industry is made up of many different companies or entities that have a common interest in creating a value product. These entities form a value chain within which different members, with differing influence in the market, work together towards a common goal. The two concepts of business models and business strategies are presented. Business models have been used to characterise the complex inter-relationships that exist between the different partners in an industry. The difference between business models and business strategy is that business models do not account for competition, which is something that strategy does.

A new model which incorporates the concepts of complementarity and substitutability is introduced in this thesis. It works on the assumption that there was a missing link from when an incremental or radical technology was introduced to how it disrupts or sustains a market. The complementarity and substitutability concept fills this void by introducing the possibility that firms that react to a new disruptive technology in different ways will result in the technology having a different type of impact in the market.

When a radically new technology becomes a reality, it will have a stronger chance of being a substitute technology by companies than a technology that is incremental in nature with respect to the existing technology. It is therefore, more probable that the substitute technology would become a market disruption. However, on the road from being a technological breakthrough to a market disruption, the adoption of the technology by companies in the industry would play a vital part in its development. Companies have strategic choices when it comes to new technological innovations: complement or substitute. A complement is one that will work with their current products. This paves the way for the technology to become a sustaining market change. A substitute resembles a threat, and paves the way for the technology becoming a market disruption. Companies therefore faced with the complementarity or substitutability of a product with relation to their current technologies or products. These differences are guided by the strategies laid out by individual companies. Business models, which are abstract representations of strategy, will then help to determine the success or failure of the technology. This is shown typically in the case of WiFi. WiFi is a wireless technology that addressed a new market, but was soon adopted as a complement by mobile operators into their suite of services. However, the future development of WiFi will enable it to possess more “mobile-like” features, thereby increasing its chances of being a substitute product to mobile technologies and becoming a market disruption. Whether it does become a market disruption is difficult to predict; but it will be a result of how mobile operators and other industry players adapt to the evolved WiFi standard.

This thesis has therefore been a study of the development of mobile and wireless technologies as well as that of market and business and shows the close interrelatedness and dependencies between them. The concepts of business models and business strategies are used to explain the development of technological products from their conception until their diffusion into the market.

Resumé

Afhandlingen omhandler udviklingen i mobileindustrien ud fra et tekno-økonomisk synspunkt. Teorier om 'forandrende' (disruptive) teknologier og relaterede teorier er undersøgt og videreudviklet. Teknologiskift bliver ofte analyseret ud fra enten en teknisk eller en markedsorienteret vinkel, men her udvikles en ny analyse, der forbinder de to vinkler.

Indenfor det mobile og trådløse industriområde bliver der konstant udviklet nye teknologier. Disse nye teknologier kan opdeles i nyskabende og forbedrede teknologier. En forbedret teknologi er kendetegnet ved, at den er baseret på tidligere teknologier og kun tilføjer få nye elementer. Nyskabende teknologier er kendetegnet ved nye innovative tiltag, der adskiller sig væsentligt fra den nuværende generation af teknologier.

Det er svært at forudse hvilke nyskabende teknologier der vil forandre markedet. Clayton Christensens (Christensen, 1997) definition af forandrende teknologi er, at den til at begynde med har en lavere ydeevne end den nuværende mainstream-teknologi og er rettet mod et andet markedssegment. Men efterhånden som den nye teknologi modnes, vil den brede sig ind på markedet for mainstream-teknologi. Hvis mainstream-teknologi-firmaerne ikke forholder sig til de nye forandrede teknologier, er det sandsynligt, at de vil miste markedsandele til de nye firmaer.

Når der indføres 3G og fremtidige netværk, er den største udfordring at forbinde disse netværk, så alle netværk kan kommunikere med hinanden. Det er vigtigt, at alle netværk er kompatible, så brugerne uden videre kan skifte imellem forskellige netværk. Teknologien, markedet og standardiseringen vil alle være vigtige for at klare denne udfordring. Teknologiske nyskabelser skal bruges til at skabe nye produkter og tjenester. Markedet og nye forretningsområder er vigtige til at skabe omsætning for de involverede virksomheder. Endelig er standardisering påkrævet på grund af de mange forskellige teknologier.

En enkelt virksomhed vil ikke kunne klare opgaven med at forbinde de mange forskellige netværk og serviceydelser. Samarbejde mellem virksomheder vil være nødvendigt. Den mobile industri består af mange forskellige spillere, der har en fælles interesse i at skabe et værdifuldt produkt. Spillerne indgår i en værdinetværk, hvor forskellige spillere arbejder sammen hen imod et fælles mål. I den forbindelse præsenteres koncepterne forretningsmodel og forretningsstrategi. Forretningsmodeller bruges til at beskrive de komplekse forhold mellem partnerne i et netværk af virksomheder. Forskellen mellem forretningsmodel og forretningsstrategi er, at forretningsmodeller ofte ikke tager højde for konkurrenceelementet, men at konkurrence spiller en afgørende rolle for forretningsstrategier.

I afhandlingen introduceres en ny model hvor koncepterne komplementerende og substituerende teknologier er tilføjet. Det sker fordi de nuværende modeller ikke siger noget om sammenhængen mellem indførelsen af nyskabende og forberede teknologier og den forandring, de afstedkommer på markedet. Koncepterne komplementerende og substituerende kan bruges til forklare sammenhængen mellem virksomheders reaktion på ny forandrende teknologi og den indflydelse, de nye teknologier vil få på markedet.

Når der kommer en nyskabende teknologi, er der en større chance for, at den vil blive en substituerende teknologi, i modsætning til en ny teknologi der kun er en forbedring af den nuværende teknologi. Det er derfor mere sandsynligt, at en substituerende teknologi vil være en forandrende teknologi. Men vejen fra at være et teknologisk gennembrud til at forandre markedet er meget afhængig af, at virksomheder tager teknologien til sig. Virksomheder foretager et strategisk valg, når der tager nye teknologier til sig. Skal teknologien komplementere nuværende teknologi eller substituere den? Komplementerende teknologi vil samvirke med virksomhedens nuværende produkter. En substituerende teknologi kan være en trussel og føre til en forandring i markedet. Når virksomheder vurderer, om nye produkter skal være komplementerende eller substituerende, vil de se på deres nuværende produkter og på virksomhedens strategi. Forretningsmodeller, som repræsenterer virksomhedens basiskoncept, kan så bruges til at vurdere, om en teknologi vil få succes eller vil fejle. Det kan eksempelvis ses ifm. WiFi. WiFi er en trådløs teknologi beregnet til et nyt marked, men er hurtig blevet adopteret af mobile operatører som komplement til deres andre serviceudbud. Men fremtidig udvikling af WiFi vil få den til at minde mere om mobile teknologier, som den måske vil substituere på et tidspunkt og derved skabe markedsforandring. Det er svært at forudsige, om det vil ske. Det afhænger meget af, om mobile operatører og andre spillere vil anvende de kommende WiFi standarder.

Denne afhandling er derfor et studie af udviklingen af mobile og trådløse teknologier og de tilhørende forretningsområder og viser, at der en tæt forbindelse imellem dem. Forretningsmodeller og strategier er brugt til at forklare udviklingen af teknologiske produkter fra konceptfasen til indførelsen på markedet.

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List of Abbreviations

AAA	Authentication, Authorisation and Accounting
ADSL	Asynchronous Digital Subscriber Line
AM	Amplitude Modulation
BER	Bit Error Rate
BPSK	Bi-Phase Shift Keying
BSC	Base Station Controller
BTS	Base Transceiver Station
CDMA	Code Division Multiple Access
CDMA2000 1X EV-DO	Code Division Multiplexing 2000 1X, Evolution- Data Only
COA	Care-off Address
CSM	Common Signalling Mode
DAB	Digital Audio Broadcast
DMB	Digital Multimedia Broadcast
DVB-H	Digital Video Broadcast- Handheld
EDGE	Enhanced Data rates for GSM Evolution
EODT	Enhanced Observed Time Difference
FDD	Frequency Division Duplex
FEC	Forward Error Correction
FM	Frequency Modulation
GGSN	Gateway GPRS Support Node
GMSK	Gaussian Mean Shift Keying
GERAN	GPRS/EDGE Radio Access Network
GPRS	General Packet Radio System
GPS	Global Positioning System
GSM	Global System for Mobile communications
HLR	Home Location Register
HSCSD	High Speed Circuit Switched Data
HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
ISI	Inter Symbol Interference
LAN	Local Area Network
MAN	Metropolitan Area Network
MBWA	Mobile Broadband Wireless Access
MIMO	Multiple Input Multiple Output
MIMO-SM	Multiple Input Multiple Output-Spatial Multiplexing
OFDM	Orthogonal Frequency Division Multiplexing
PAN	Personal Area Network
PDC	Personal Digital Cellular

PDP	Packet Data Protocol
P-PAN	Private Personal Area Network
PSK	Phase Shift Keying
P2P	Peer to Peer
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
RFID	Radio Frequency Identification
RNC	Radio Network Controller
S-DMB	Satellite- Digital Multimedia Broadcast
SDR	Software Defined Radio
SGSN	Serving GRPS Support Node
SLA	Service Level Agreement
SNR	Signal to Noise Ratio
TDD	Time Division Duplex
T-DMB	Terrestrial- Digital Multimedia Broadcast
TD-SCDMA	Time Division Synchronous Code Division Multiple Access
UMTS	Universal Mobile Telecommunications System
UHF	Ultra High Frequency
UWB	Ultra Wide Band
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
VSF-OFCDM	Variable Spreading Factor- Orthogonal Frequency and Code Division Multiplexing
WAN	Wide Area Network
WCDMA	Wideband Code Division Multiple Access
WiBro	Wireless Broadband
WiFi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
S-OFDM	Scalable Orthogonal Frequency Division Multiplexing
WLAN	Wireless Local Area Network
WWAN	Wireless Wide Area Network

1 Introduction

1.1 Overview

Change characterises the mobile industry today. In one way or another, our daily lives have been transformed because of mobile technology and services. This is one technology arena where the interplay between innovation and market makes it such an exciting and interesting place. As this momentum continues, it will propel the industry towards the future generation of mobility. The pace of new technology entering the market is rapid and new devices and services are constantly appearing. Old technologies are replaced with more efficient new ones and the magnitude of this growth from its humble analogue beginnings to today's content rich and high speed data services were quite unimaginable just ten years ago. The pace with which mobile technology research and development takes place typify the industry and the excitement and interest surrounding it. The extent of research and development work done here has given a strong foundation for the industry. Without all this work done on technologies relating to networks, air interfaces, coding, modulation techniques and other advances, the mobile industry would not be what it is today. The multitude of contribution by educational institutions, companies, governmental agencies as well as many other organizations and individuals have all come together to define mobile telecommunications as it is today.

What is mobile telecommunications all about? When it was first conceived, the most important feature was that it enabled people to have the ability to communicate with mobility. To make telecommunications mobile, it was inevitable that many technical difficulties would be encountered. Mobile telecommunications started out as an analogue technology. Handsets of the earliest form of mobile telecommunications were large and bulky, unlike what we have today. Their only function was voice calls.

Mobile telecommunications has come a long way since its conception in the 1960s. While many saw the ability to have mobility while talking on the phone as a true enhancement of its capability, others saw it as a revolution. The earlier group saw mobile technology as an evolution of technology from fixed to mobile. It was seen as an evolution because the idea was still the same: to have calls. Technology that was used in fixed telephony was also needed in mobile telephony, such as speech codecs. The later group saw it as a disruption to fixed telephony- a revolution indeed. The reason being that mobility was such a new, novel aspect of telephony that did not exist before. Also, while technology from fixed telephony was still required with mobile telephony, the size of development in new technologies to allow mobility far exceeded this. Both camps are of course correct in their description. Mobile telephony can be both seen as evolutionary and revolutionary: Evolutionary, because it is evolved from fixed telephony; and revolutionary, because it is based on an entirely new technology platform.

The mobile industry is a fast changing one with new technologies appearing all the time. Some of these technologies will be part of the future but some will fail. Once mobile telephony entered our lives, changes to our way of doing things occurred and further development of mobile telephony soon made it possible for the masses to obtain a handset to communicate on the go with friends, family and business. Analogue systems were replaced by digital systems to enable more efficient use of spectrum and also increase the number of users possible at one go. These all led to the explosion of growth of mobile telephony worldwide.

As the industry moves to the new stage of its evolution, a lot of uncertainty and questions over the different wireless technologies that are available have arisen. The once accepted evolution of technology from Global System for Mobile communications (GSM) to WCDMA (Wideband Code Division Multiple Access) or Universal Mobile Telecommunications System (UMTS) has also been questioned mainly due to the emergence of several new wireless technologies that could be used as alternatives to WCDMA [1][1] [2]. The high prices paid for licences in Europe and also costs of new infrastructure have also been rather painful for operators. In parallel to WCDMA, development and deployment of Code Division Multiple Access 2000 (CDMA2000) has proven successful in Japan, South Korea and the Americas [3]. In South Korea and Japan, 3rd Generation networks are based on either WCDMA or CDMA2000, without the exorbitantly high licence fees that European operators had to contend with. Technologies such as CDMA2000 1x Evolution Data Only (CDMA2000 1X EV-DO), Time Division Synchronous Code Division Multiple Access (TD-SCDMA), EDGE (Enhanced Data rates for GSM Evolution) and also Worldwide Interoperability for Microwave Access (WiMAX) and Mobile-Fi[2] are now being developed and some have been deployed [3] [4]. Network operators are now considering these other alternatives to WCDMA that could potentially be used instead of WCDMA.

As mentioned in the previous paragraph, new technologies are always being introduced to the market. Some of these may at hindsight be disruptive to mainstream technologies. Mainstream technologies refer to those that are already accepted in the market and which have the largest proportion of the market share. Based on Clayton Christensen's definition of a disruptive technology, it is one that may initially have a lower performance than the mainstream technology and is aimed at a different market segment (Christensen 1997). But as the technology grows, it will also occupy a place in the market of the mainstream technology. If mainstream technology firms do not

[1] [] represents a link to an Internet source, which may be found on Page 254.
[2] This is the name given to the 802.20 standard by Forbes Magazine.

address the disruptive technology, it is likely they will fail and the new disruptive firm will grow in size and importance in the industry. A lot has happened in the mobile industry including the introduction of 3G with high licence costs and WiFi entering the market [5]. WiMAX, and to a certain extent, Mobile-Fi have also been considered by within the industry as being disruptive in nature to 3G [6] [7]. In theory, the technical possibilities of such technologies do make them good alternatives to 3G or other mobile technologies. However whether they do become disruptive remains to be seen. Christensen mentions that a disruptive technology should be based on market possibilities rather than technological. Using this as a reference point, it should then be mentioned that the target market of new wireless technologies should be different from that of mainstream technologies (e.g. 3G), if they are to be considered disruptive in nature.

1.2 Different Types of Technology in Brief

Mobile telecommunications as we know today is possible only because of the technological advancement that has been made since fixed telephony was introduced to the commercial market. Research in the areas of signal processing, air interface and others have seen to the vast improvement in mobile telecommunications. Battery power has increased while units became smaller; speech quality and reception has improved since the first mobile phones were introduced. The introduction of simple data services have since evolved to that of high speed data services around the world.

In the 1980s, the first analogue mobile telephone system was introduced. Compared to 2nd and 3rd generation mobile systems, this was a very primitive system. However, this marked the beginning of mobile telephony. In the early 1990's, the first digital mobile telephone systems (known today as 2G) were introduced. As the number of users grew, the system proved to be too inefficient and a newer, more efficient was required. This need heralded in the next generation of digital mobile telephony. The most popular of these was that of GSM which is widely used on a global scale today. Today, there are around 1.6 billion GSM subscribers worldwide[3]. Simple data services soon became popular with GSM users and soon other more bandwidth intensive services were introduced to users, as networks evolved from circuit switched to packet switched, and thus moving towards 3G. The development work of 3G took longer than it should have and roll-out of 3rd generation networks only started to take shape in the early 21st century, with Japan taking the lead with the introduction of 3G services in 2001. Work continues with 3G and with enhancements to 3G, to ensure that users will get high speed mobile communications as and when they want it.

[3] http://www.gsmworld.com/index.shtml - cited 140206

Ubiquity and heterogeneity amongst networks is something that both network operators and equipment manufacturers are aiming for at present. To have interconnectivity and interoperability amongst different types of networks is what true mobility is all about, where users will never be without at least one method of access to the communication. In a true heterogeneous network, a user will be able to make use of his/her device, and connect to the mobile network, the local area network or the personal area network whenever it is needed. Network roaming will be seamless and of costs will be low and attractive. The use of data services and applications is growing each day since the surprising success of SMS. Internet connectivity, email services, location based services, music download and video streaming are some of the services that are available with 3G networks today. In the future, more advanced forms of location based services and high quality streaming of movies and TV programs will be available. The mobile industry is constantly moving forward. Even as 3G is being established, work on beyond 3G or 4G technologies have already begun. In Japan and South Korea who are the leaders in 3G, research and development work on 4G technology started back in the 1990s. One of the technologies of great interest is that of Variable Spreading Factor-Orthogonal Frequency and Code Division Multiplexing (VSF-OFCDM), which allows for even higher data transmissions of up to 300Mbps[4] [5] outdoors and up to 1Gbps indoors (Larson 2003). 4G is still very much undefined and most operators are still coping with 3G and how to make 3G successful. However, there are many projects that look at the development of 3G in different scenarios and one example of these is the IST-MAGNET project. Development work on beyond 3G or 4G technologies is currently limited as work on enhancements to 3G such as High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access[6] (HSUPA) are developed and deployed to enhance 3G networks.

The different technologies today are all aimed at different range or coverage [2]. Coverage has always been something that mobile operators strive for in a network. However, new types of networks that do not necessarily require so large a coverage area due to its nature and more trade off with data transmissions have entered the industry. Figure 1 gives an example as to how the different types of technologies may be represented by different network types.

[4] http://www.infoworld.com/article/04/06/04/HNntt4g_1.html - cited 051205
[5] http://www.thestandard.com/article.php?story=20040604190846415 – cited 051205
[6] http://www.4g.co.uk/PR2004/March2005/2050.htm - cited 130206

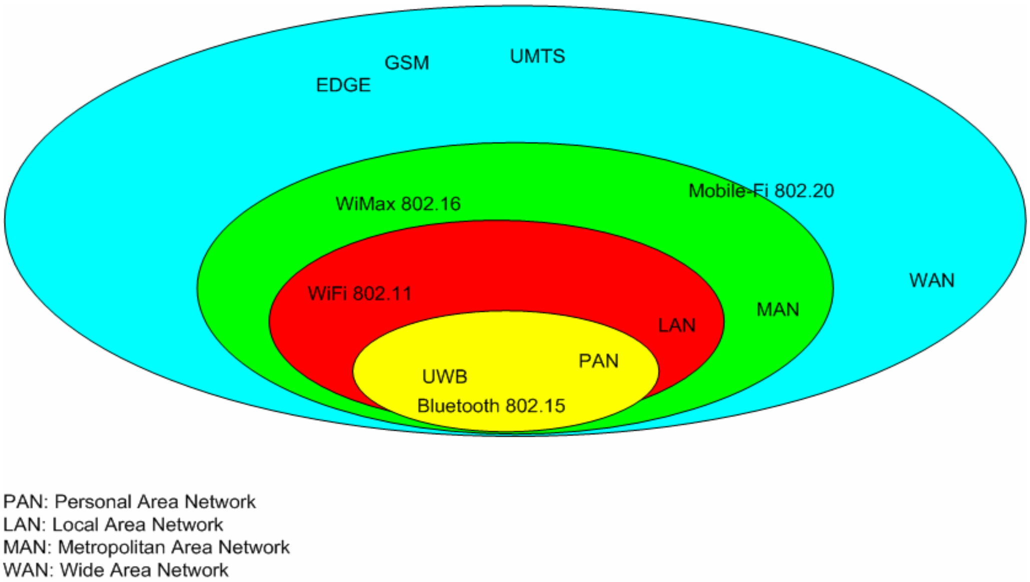


Figure 1. Different wireless/mobile network types.

Table 1 lists the main mobile and wireless technologies that are in operation and/or others that are still being developed around the world today. This list is not exhaustive but is meant to show the wide variety of technologies available and the amount of work required in making interconnectivity and inter-operability possible.

Range	Technology
	Bluetooth
Personal Area Network	UWB
Local Area Network	WiFi
	WiMax
Metropolitan Area Network	Mobile-Fi
	GSM
Wide Area Network	UMTS

Table 1. List of the main mobile/wireless technologies.

From the list, the categorisation has been made in terms of range. Personal Area Network technologies or sensor networks include technologies such as Bluetooth, and

UWB (Ultra Wide Band). The most popular form of Local Area Network is that of WiFi. Metropolitan Area Networks would include the newer technologies of WiMAX and Mobile-Fi. Wide Area networks would include GSM and UMTS. Now it is seen that if the categorisation of networks is done in this manner, it can be inferred that the different technologies have target markets and therefore the earlier definition that disruptive technologies should be viewed from a market perspective holds true in these cases. Each of these categories represents different segments of the market. Some users require global roaming capability that is available only with GSM. Others require shorter range Bluetooth connectivity to connect their computers to the printer nearby. There are therefore sufficient segments within the market for each of these technologies. The technologies categorised according to their range is one way in which industry can segment the market. Of course, there are also various other ways to segment the market.

1.3 Interdependency between Technology and Business

There is an intricate link between technology and business. In today's competitive technology industries, technology alone cannot sustain the industry. Business practices, business models and strategies also play an important part in technology business today. In particular, current business practices have shown growing interest to the concept of a business model. This concept is still rather unclear but in general, it refers to the description of relations and processes that take place within a value chain and amongst entities within an industry in order to produce an end product. Business models have been used to characterise the complex inter-relationships that exist between the different partners in an industry. Revenue flow, service and process flows are all a part of a business model. Business models indicate where partnerships or relations should be formed in order to best produce the end product. But it does not describe the strategy that is required to get the product to the end users or how it should be marketed (Magretta 2002) (Seddon and Lewis 2003). This is the job of the business strategy of the company. Technology products require many years of development for a prototype product to be available. A business model should work hand in hand with technology in the creative processes to ensure the development of the product and the final output.

The evolution of mobile technology coupled with the emergence of new technologies adds to the complexity of business models that companies in the industry should adopt. Business models are not static and are constantly evolving, as technology advances. This inter-dependency of and inter-relationships between technology and business is seen as vital to success within the mobile industry today. New business models may have to be created as new technologies are developed. As industry support for new technologies is what ensures its success, it is likely that companies will pay a large attention to any potential disruptive new technology that enters the market.

The disruptiveness of new technologies will not only be looked at from a technological standpoint but also from a market perspective as these two are very much connected in today's mobile market. The market perspective is important as it is here that financial success of a technology or innovation may be determined. Innovation theory, and in particular, the theory of disruptive technologies as written by Clayton Christensen, will be used to analyse potential new disruptive technologies in the market and how technology, market and other factors play a part in the success of any technology (Christensen 1997).

When there is a technological innovation, this innovation is categorised generally either as a substitute (in which case it could compete against the existing technology) or it could be a complement (in which case it would work with or be harmonised with the existing technology). Often, it is only when a stance is taken by the company that has the existing technology know-how, can the innovation lead to a market disruption or a sustaining market. Whether a technology is incremental or radical is by and large a technology analysis. However, when the product is put to the market and associated with either being sustaining or disruptive, it becomes a market analysis. The pointed difference here is the scope of analysis to ascertain how disruptive the new innovation is and to make a choice as to which innovation to adopt into the company's future business strategy.

1.4 Problem Definition

This thesis traces the evolution of the mobile industry and also looks at the different paths that today's mobile operators can take. The evolution path of mobile technology will start with the GSM standard and the CDMA technology and will trace the paths of different operators in evolution to 3G. The different 3G standards of WCDMA, CDMA2000 1x EV-DO and TD-SCDMA will be studied. Other than 3G technologies, improvements to the GSM standard with General Packet Radio System (GPRS) and EDGE are also considered. Wireless standards have also appeared in the mobile and wireless industry. These include Wireless Fidelity (WiFi) or Wireless Local Area network (WLAN), WiMAX and Mobile-Fi as well as other wireless standards that may be proprietary in nature in the industry. All these different technologies, both mobile and wireless will be looked at.

With the appearance of so many new technologies, the number of operators and vendors will no doubt increase and there will be changes in the roles they play in the industry such that they may take on more than just one role (either as a multi-technology vendor or as vertically integrated service providers, etc.). With users wanting the cheapest possible connection possible at any one time, it is therefore to the benefit of operators to interconnect with one another such as a WCDMA operator interoperating with a WiFi operator. The possibilities of these are already being realised with interconnectivity between WCDMA networks and GSM networks.

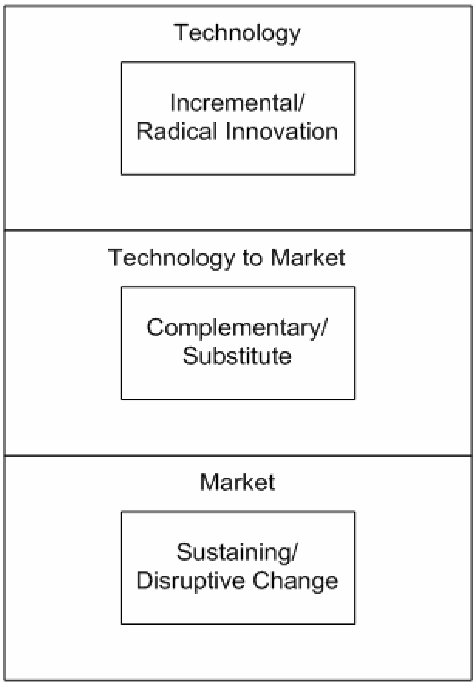


Figure 2. Analysis of disruptions.

Taking Christensen's theory of disruptive technology as a point of departure, we would analyse innovation on two different levels. Christensen's' theory is valid only in a market sense. However, technology disruptions are what leads to market disruptions and so the analyses should be done on two different planes. To explain this further, Figure 2 will be used.

From a technology standpoint, some of these newer technologies such as WiMAX and possibly Mobile-Fi may be considered to be radical innovations. They could in time be a substitute to WCDMA (UMTS) networks and halt any further development of WCDMA. But at the same time, they could also be viewed as being complementary technologies. Many operators also view at least some of these technologies as possible alternatives to the costly WCDMA (in terms of licence fees and infrastructure). Figure 3 shows how the different technologies may be categorised in terms of mobility and its substitutability to UMTS. A technology will not be disruptive or sustaining until it is viewed either as a complement or as a substitute product. Only then will it be decided whether it will disrupt or sustain the current technology. This thesis will explore the theory of disruptive technologies and how it applies to the mobile market. It does not ignore technology *per se*.

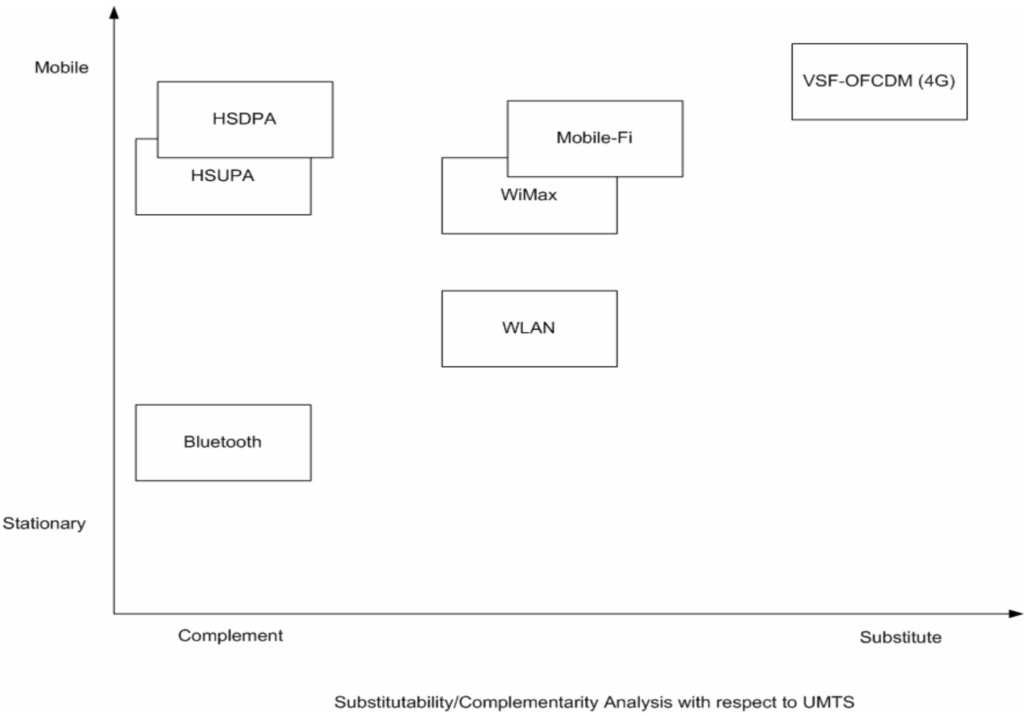


Figure 3. Substitutability/complementarity analysis, with respect to UMTS.

To put things into perspective, UMTS is taken as the starting point of the study. There are several reasons for doing this but the most important reason is that UMTS has been known to the mobile industry for quite some time but has taken several years to realise. And it is only today that network roll outs are taking place at a considerable speed. Another reason is that UMTS is the first mobile system that was planned from an early stage to be a global standard, with governments, industry and individuals working towards the many aspects of this technology. Figure 3 shows the substitute-complement analysis with respect to UMTS.

Generally speaking, radical technological innovations result in new markets. They may have significantly lower performance attributes when compared to the original (mainstream) product. However, as this technology grows and develops, it is able to soon compete in the original market and take over the old product. Using Clayton Christensen's The Innovator's Dilemma as starting point, this thesis will evaluate the mobile industry and the different technologies as possible disruptions and how this may change the path of the players in the industry of today. Sustaining technological changes are evolutions or upgrades of the previous mainstream technology. Sustaining technologies are those that help to increase the life span or have features that are added to the original product to sustain that technology, resulting in improvements made to ensure increased performance and quality to the original product as well as to add new features. This is usually done in response to competition or the introduction of disruptive technologies and the available of discontinuous technologies.

Technology alone cannot ensure the success of the product. With today's mobile products, coupling between technology and business models are an important component in many industry partner's agenda. It is of course quite difficult to predict what is going to be the 'next best technology'. However, with clever business modelling and strategies, most technology products can enter the market and have at least a margin of success.

There are many planes upon which disruptiveness may be analysed. Christensen has chosen to do this as a market phenomenon. However, because of the close interrelatedness between technology and market today, the analyses provided in this thesis expands on his explanation to include how it can be seen from a technology stand point. The suggestion here is that technology innovativeness does not lead directly to a disruption or a sustaining change. There is another level in which it should be analysed and this is whether the innovation is viewed by the companies involved as being one of substitutability or one of complementarity.

Whether a technology innovation is taken to be a disruptive change or a sustaining change is also very much dependent on a company's business strategy. The strategy will be dependent on whether the new technology is conceived to be one with substitute characteristics or complementary characteristics. Once the strategy has been decided, the business model with which to work with will be of considerable importance as it defines how the processes and inter-relationships between different partners and other parties should be executed.

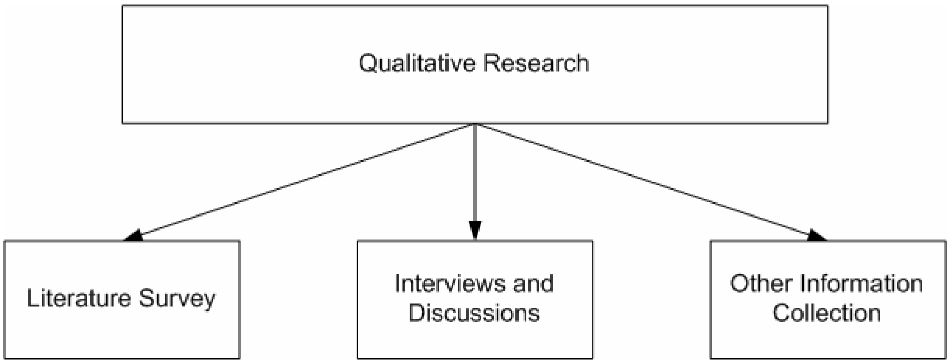
1.5 Research Methodology

This section describes the methodology used in this thesis. Methodology can be referred to as the theoretical analysis of the methods appropriate to a field of study or to the body of methods and principles particular to a branch of knowledge[7]. It can also be described as a method in scientific and technical contexts[8].

Given the fact that this study involves two distinct but related disciplines, its focus is necessarily broader in scope and orientation. This inter-disciplinary approach, however, more fully captures the nature of the specific research inquiry and provides a more nuanced analysis. The problem is unbounded in the sense that its solution cannot be prescribed by the application of a rigorous methodological approach. This being the case, a methodology was devised to more fully explore the constellation of related problem areas associated within this field of study and which best reflects the combined scope of the research.

A principally qualitative research method was chosen because qualitative research methods are designed to help researchers understand a particular phenomena and that understanding this “from the point of view of the participants and its particular social and institutional context is largely lost when textual data are quantified” (Kaplan 1994). Qualitative data sources include interviews, documents and texts, and the researcher’s impressions and reactions (Myers 1997).

Due to the large amount of texts and documents that had to be reviewed and analysed, both on the Internet and in physical form, a research methodology based mainly qualitative analysis was chosen in this thesis. Some empirical data collection has also been done.



[7] http://dictionary.reference.com/search?q=methodology – cited 130105
[8] http://dictionary.reference.com/search?q=methodology – cited 130105

Figure 4. Three different methods used for information gathering

The qualitative methods used in this thesis have been combined with a multi-disciplinary approach. This was mainly due to the inter-disciplinary nature of the research undertaken. By inter-disciplinary, it means that different aspects of technology evolution have had to be looked at. This proved to be a challenging task and an inter-disciplinary approach to identify and analyse the different disciplines of technology, market and standardisation aspects had to be engaged, in order to contribute to a fuller understanding of the mobile and wireless market. The research work has been based on Figure 4. Three different information gathering methods were used in order to facilitate the research work.

1.5.1 Literature survey

The literature review of this project had to cover a wide range of topics. Technology related literature sources as well as those relating to innovation theory and economics theory had to be studied. The analyses of different technologies in the mobile and wireless industry today, as well as different angles of innovation theory and economic theory have been important in outlining the area of research. Not only is theory an integral part of the study; but also practical market descriptions and industry specific characteristics and challenges had to be evaluated. Different areas of research had to be looked at. These include:

1) Mobile and wireless technology development
2) Innovation theory and theory of disruptive technologies
3) Industry related development and challenges
4) Economic theories
5) Business models and business strategies
6) Standardisation

As the thesis is related to the development in the mobile and wireless technologies, literature representing the latest engineering and scientific development was chosen for background reading. Due to the large amounts of literature available in mobile and wireless technology development, only those presenting general perspectives will be chosen in the literature review. The literature was chosen to give a broad overview of technologies and their current developments.

The thesis has made use of disruptive technology theories and Harvard Business School has several high profile researchers on this topic. One of the most famous and most quoted is that of Clayton Christensen. His book, The Innovator's Dilemma has laid the foundation of this thesis and is taken as a point of departure for further development. A clear understanding of this theory and relating subjects were needed to propose a link between technology and market.

Industry related developments had to be closely followed, through literature published by companies in the industry or through industry magazines and journals. Another source of literature that is closely related to industry development is that of consultant reports. Other identified sources include the ITU website, UMTS Forum website, CDG website and IEEE website. White papers and articles with information on technology development and related activities within the industry were also chosen to provide the main source of literature for study in this area.

Economic theory played a large part in the analysis of how companies in the mobile industry operate. There are many facets to economic theory and some will likely contribute opposite views. However, the importance of economic theories lay in the fact that they offered valuable insights into how organisations develop and how businesses develop in the mobile industry. The works of several authors of economics such as Schumpeter, Porter and others have been studied to obtain a good appreciation of the intricacies of economics and market theory. A literature review of economic theories relating to market cooperation and competition has also formed a part of the initial literature study.

The role of standardisation has also been seen to play an important part in the progress of the industry. Standardisation plays an important role in shaping the direction of a particular technology. Therefore, to give a complete picture of the industry and as one of the central factors affecting technology, a literature study on standardisation had to be done.

Business modelling and business strategies shape what companies will do in the light of new technologies. Therefore a literature study encompassing both business modelling methods as well as business strategies had to be carried out. The differences between the two were also important so that no ambiguity amongst the terminology would ensue.

The significance of the literature study is based primarily on the fact that different innovation and economic theories had to be used in this thesis. The selection of relevant material has been based on their closeness to the topics of the thesis. Material has also been selected based on their academic contribution and contribution to the industry (such as conference or journal papers). Also, the advances and changes in technology are occurring at a very fast rate so it was therefore noted that continual updating of knowledge and information, based on industrial as well academic sources, would be required throughout the project.

1.5.2 Interviews and Discussions

Several interviews have to be conducted with relevant personnel from the mobile industry. The list of interviewees may be found in Appendix 2. Through these interviews, an industry perspective of the future has been obtained. The selection criteria for interviewees are as follows:

1) Relevant industry experience
2) Continual contribution to ongoing projects in their field
3) Ability to provide industry insights

The contribution from interviews with people involved in different development aspects of the mobile and wireless industry has played a significant part in the overall study. The practical nature of the research required input from parties such as device manufacturers and mobile operators. It was therefore essential that the appropriate people to interview and get information from were found. The interviews have been obtained through the following channels:

1) Working in the IST-MAGNET project and getting inputs from industry partners
2) External PhD research stay at Nokia Corporation in Espoo, Finland.

Each of the persons interviewed were asked a different set of questions. The questions asked were related to their field of work and they have provided answers to some of the different questions posed in the thesis. The answers and feedback given by interviewees have been used in different parts of the thesis to support arguments and to provide examples. It was expected that with industry experts certain company bias would exist. This point was noted from the start and should therefore in no way have presented an unbalanced or biased view in the thesis.

Other less formal discussions relating to topics in this thesis were also carried out with industry experts as well as academics.

1.5.3 Other Information Collection

Knowledge of technology progress and business strategy and innovation theory has also been obtained through PhD courses throughout the study. PhD courses were seen as an instrumental part in the understanding of the technologies to be studied. The chosen courses have provided relevant information on the topics. The recommended course material often consisted of fundamental material relating to the topics and thereby provided an essential reading list. Courses in innovation theory and business strategy have provided extensive understanding of the fundamentals behind these subjects and have contributed to a more nuanced approach in discussing these topics in the thesis. Because of the multi-disciplinary nature of this thesis, it was believed that courses corresponding to different dimension represented in the thesis were required to present differing views. It was also felt that such information was a requirement when one looks at technology change and how new technologies could lead to potential disruptions in the market.

Trends in the mobile and wireless industries have also been followed by attending talks and presentations by industry leaders. This has often proven to be a good chance to see and hear what companies think of the future of the mobile industry and thereby acquiring a fuller perspective of this view.

1.5.4 Case study

A case study of WiFi development had been chosen to represent the trends of the market and it has been used to emphasize some of the points made in the thesis. Therefore, the case study here does not represent a research method but rather a unit of analysis, as qualified by Myers (Myers 1997). As the mobile and wireless industry has been introduced to several new technologies in the recent past, it was found to be quite difficult to support a case study on a new technology due the lack of written material and sources of information. Most of the newer technology studies would likely not have provided sufficient information and data for a proper study to be completed. Therefore, the choice of a WiFi case study was determined by the following factors:

1) Relation to the topics discussed in the thesis
2) It should be a recent development (limited to the past 10 years)
3) Availability of up-to-date qualitative information
4) Availability of sound empirical data

One of the difficult tasks was to determine the ‘soundness’ of empirical data. The empirical data used was expected to be correlated with increase in use of the technology in question. In this research, mainly Internet sources have been used with some use of published work. This was to be expected. The Internet has been able to provide the latest and therefore most accurate empirical data. To ensure the credibility of the data collected from Internet sources, at least 2 different websites have been cross-referenced with one another.

1.5.5 General Research Questions

Mobile operators have traditionally been the leading players in mobile service deployment. With the advent of other wireless networks such as WiFi and WiMAX, mobile operators may still take the lead and be the dominant market player. However, this may also change. It is also likely that new WiFi or WiMAX operators that control public access wireless networks would become dominant players in the future and take over the role of the present mobile operators. Having spent large amounts of money on 3G licenses, it will cost even more for operators to start deploying the 3G infrastructure. Furthermore, how the present day mobile operator copes with new players in the wireless and mobile market and the type of business models will they will use will be looked at. Differences between the business models of the industry today will be compared to what it may look like in the future. It is clear that the current business models and the players in the value chain will have to change in order to take into account the new features of next generation mobile and wireless solutions.

In order to understand how new business models may be adopted, it is necessary first to understand the different technologies and the advantages of each of them. Interconnectivity between different types of technologies will pose problems and these will affect the possibility of business and market. Interconnected networks will face some issues with regards to interoperability and these will also be studied. With that in mind, several research questions are formulated and used as a guide through the research.

1) The theory of disruptive technology will be used as a basis of analyses of how newer technologies may come to displace current technologies. How will potential disruptive technologies change the path of mobile technology evolution?

2) Different networks are now being interconnected. To achieve a truly ubiquitous and heterogeneous network, different types of networks will have to be interconnected and interoperable. How important is seamless roaming and availability of services?

3) Different technologies and companies will have different goals and thus different business models. How will the business models of entities such as the mobile operator and device manufacturer evolve to respond to changes in technology and implementation?

The overlap multi-faceted nature of this thesis calls for a multi-disciplinary approach to the methodology. Conventional sources information such as books, scholarly journals and conference publications of will be used; but information sources will also be from other sources such as the Internet, interviews and industry publication. Both theoretical information as well as practical industry based sources of information will have to be used in the analysis of the subjects in this thesis. The final outcome will therefore be a combination of theoretical concepts as well as practical inputs that are analysed in a systematic manner. It was noted in the beginning that changes to the original approach and the addition of new topics could occur during the course of the project. This has, however, not interfered a great deal with the overall project methodology described here.

1.6 Theoretical Framework

The study makes use of the following framework in relating the different aspects of the thesis. The business model and business strategy depend on one another to deliver success to the firm. The business model is treated as an abstract description of business strategy of a company. The business model is a description of the flow of services, technology, finance and organisation within the company and outside it (i.e. with business partners). The business strategy of a company, however, is more concerned with competition between firms and how one company can do thins such that it becomes the leader in the field. Magretta suggests that a business model isn't the same thing as a strategy and that business models describe how different components of a business fit together but they lack one critical dimension of performance: Competition (Magretta 2002). Seddon and Lewis strategies are treated as grounded firmly in the real world whereas business models are abstractions of the firms' real-world strategies (Seddon and Lewis 2003).

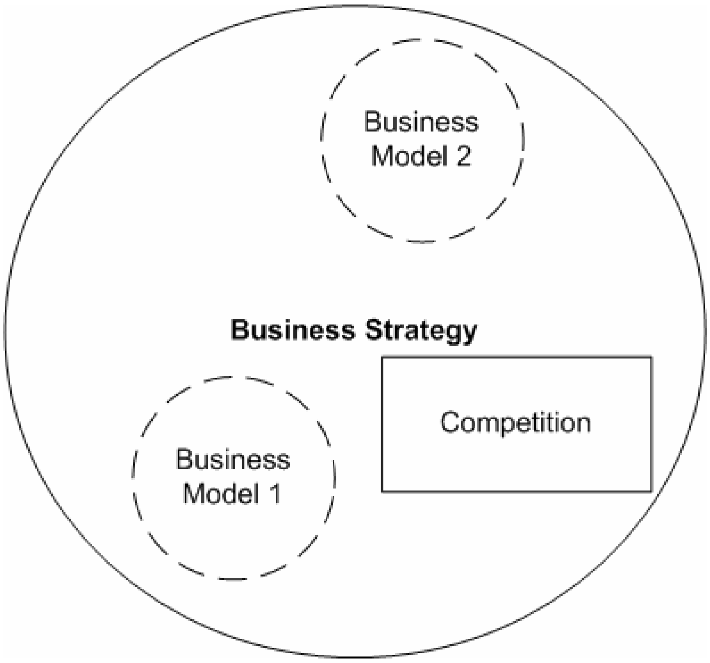


Figure 5. Representation of business strategy and business model
Adapted from (Seddon and Lewis 2003)

Figure 5 is a simple representation of concept of business strategy and business model. Whereas a business strategy is the entirety of business including competition amongst firms, a business model is something that is conceived to represent the strategy of the firm. Therefore, it depicts that a company can have more than one business model at one time, depending on its strategy. And that the business models are subsets or a part of the strategy of the company. Competition is an integral part of business strategy but not of a business model and is therefore represented as a separate component of business strategy. Competition relates to the struggle or contest between firms in order to become the industry success. Competition between firms ensures that companies will strive towards efficiency and that prices will be kept low for end users.

Strategy is what differentiates one company from another. They may operate similar business models but the differentiating factor is how they choose to compete. How it competes and what it does to gain the upper hand in the market including its reaction to radical and incremental technologies are part of the strategic study a firm has to do. Once a strategy has been decided, the business model will be used as a tool to describe relations with partners and how processes will flow amongst members of the value chain in providing the technology or product. How the business strategy is translated into a description of logic flow is the business model. While strategy decides whether a radical or incremental technology could become a substitute or complementary to present technologies; it is the model that would describe the processes and relationships needed in order to make a disruptive or sustaining change in the market.

Whether a radical or incremental technology becomes a complementary or substitute technology or product will depend very much on the business strategy of the company. This is based on its competition analysis of the market and how it chooses to compete in the market. Whether a complementary or substitute technology will lead to a disruptive or sustaining change in the market will depend on the business model of the company which describes how the technology or product will be delivered to the market. The business strategy is what determines the future actions of the company and its direction while the business and thereby the policies towards new technologies: whether they will be complements or substitutes to existing products. The model, on the other hand, based on the strategy of the company works towards establishing the new product in the market determines if it is a disruptive or a sustaining change, with respect to existing market products.

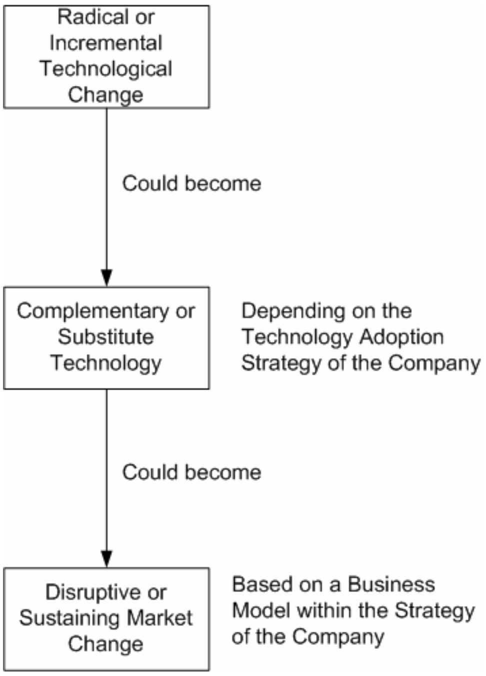


Figure 6. Relationship between technology, business strategy, business model and market

Figure 6 depicts this relationship. Here, we see the flow from technological change to type of technology as viewed by the company to how the market views the technology. And concurrently, how the business strategy influences the view of the technology by the company and how the business model within the strategy of a company plays a part in how the product finally reaches the market.

Technology is constantly changing and new innovations in technology will lead to changes in the market. But the route from technology to market is a long one, decided by many different schemes of companies and other factors. The complex relationships between technology and market are followed using the concepts of business models and business strategies. The framework used in this thesis is that radical technological changes most likely lead to disruptive market changes. But these are in turn determined by the business model and business strategy that is adopted by the firm. It is the strategy that decides the firm's decision in adopting a complementary or competitive stance towards a new radical technology and the business models establish whether a sustaining or disruptive change will be seen in the market place.

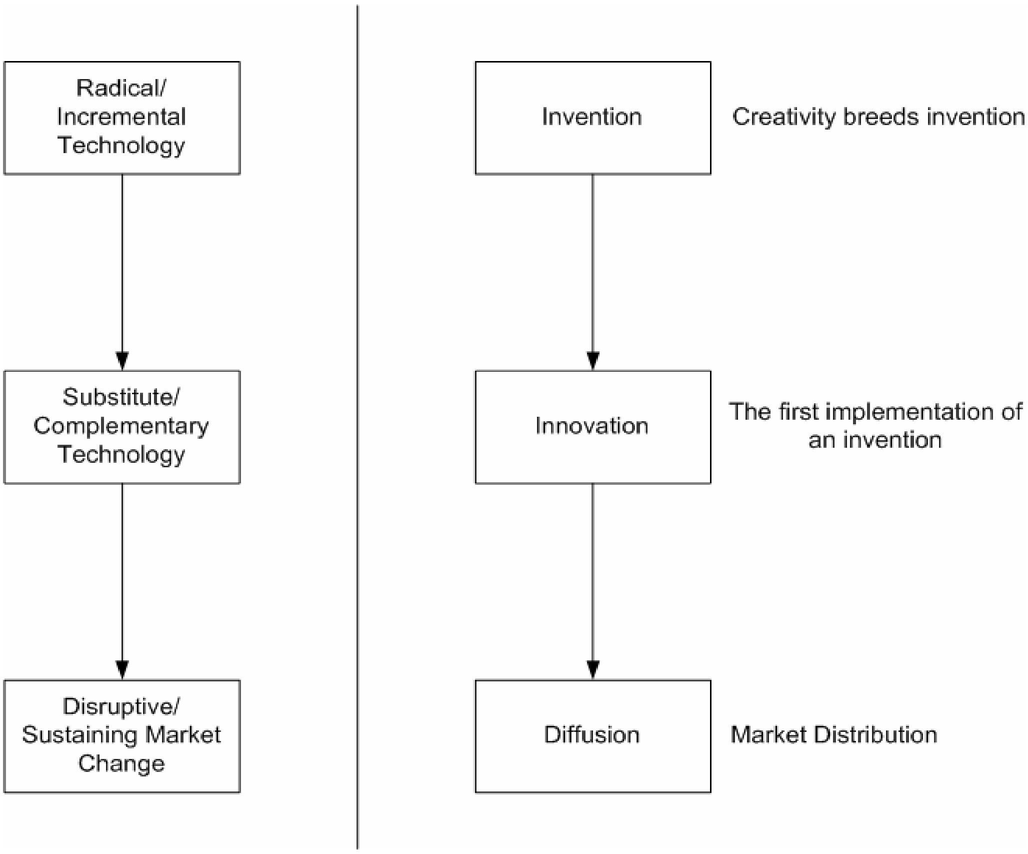


Figure 7. Relationship between the Invention-Innovation-Diffusion model and technology, substitutability and disruption.

This is somewhat related to the model of Invention-Innovation-Diffusion. This popular model is based on the "Trilogy of Invention-Innovation-Diffusion", which was referred to by Schumpeter (Mahdjoubi 1997). Schumpeter made the distinction between an invention and an innovation. Figure 7 shows the steps of the Trilogy model and how it relates to technology change.

1.7 Expected Results

The expected result of the research is to have an in-depth discussion and analysis of the relationships between different technologies and business elements as the mobile industry moves to the next chapter of its development. The part played by disruptive technologies will be looked at and how business models may change because of them.

By looking at the inter-relationships between the different determinants in the 3G arena, it is expected that the following results be achieved:

1) An analysis of potential disruptive technologies in the mobile industry and how do market disruptions occur.
2) A discussion of the structure of the ICT industry of the future and identification of new market players.
3) An analysis of new business models to be adopted by mobile operators, taking into account disruptive technologies and new market players in a heterogeneous network scenario.

The above will be achieved with the following contributions:

1) An examination of the different technologies: WCDMA, CDMA2000 1x EV-DO, TD-SCDMA, EDGE and other wireless technologies.
2) Studying interconnectivity between different types of technologies and how this will lead to changes in the mobile business.
3) Important interoperability issues of interconnected networks will also be looked at.
4) An examination of how the business models and strategies of different players in the mobile industry may change in the future.
5) An in-depth case study of WiFi.

1.8 Structure of the Thesis

Chapter 2 studies Clayton Christensen's theory of disruptive technology and also examines where this lies with respect to other innovation theories. A possible development of Christensen's theory based on an Invention-Innovation-Diffusion model is also examined.

Chapter 3 presents an overview of the different technologies in the mobile market today and examines some of the new technologies that could be introduced into the market in the near future. It also looks at the definition of 4G and what technologies could constitute 4G.

Chapter 4 considers the evolution of technologies to 3G and beyond. Some of the technical considerations that go into technology evolution are examined here. A description of the evolution paths of mobile and wireless technologies is also provided here.

Chapter 5 looks at the business and economic considerations that are involved in the evolution of mobile and wireless technology. Economic theories are examined closely in relation to their impact to the mobile and wireless industry.

Chapter 6 is a chapter about standardisation and it examines the different types of standards development organisations in today's mobile and wireless industry. This chapter also examines the implications of standardisation on innovation and the direction of standardisation organisations.

Chapter 7 studies the concept of a business model and how it is applied in the industry. The concept developed by Faber et al has been used to analyse the mobile operator's and the device manufacturer's business models.

Chapter 8 first gives an overview on the differences between business models and business strategies. It then goes on to examine the business strategies of the mobile operator and the device manufacturer and how strategies affect choices of companies in relation to radical technologies.

Chapter 9 discusses the main points of the thesis and provides a conclusion to the thesis.

2 Theory of Disruptive Technologies

The theory of disruptive technology has been studied widely as a part of Innovation theory. Incorporating research in Product and Process innovation, as well as techno-economic analyses of technology markets, disruptive technologies have gained much interest of companies in technology related areas.

One would think that a disruptive technology would be one that introduces technological qualities that are overwhelmingly better than the original product and thus cause a disruption in the market of the original product. This is, however, not the case, according to Clayton Christensen's book "The Innovator's Dilemma" (Christensen 1997). Using his book as a starting point, it depicts a disruptive technology as one that initially has lower performance and qualities as compared to the original product. As time passes, development on this technology will allow it to surpass the original product in terms of performance and thus overshadowing and taking over the original product market. A disruptive technological change is always classified as one that has a lower initial performance. It also addresses a different market segment compared to the original product and thus competes on a different set of issues and priorities. A disruption is also one that can be a new market disruption or a low end disruption.

2.1 Clayton Christensen's Theory of Disruptive Technology

The theory of disruptive technologies, as written by Clayton Christensen, is one that can be applied to most technology related industries, both in the past and today. This book was written in 1997 and gave an insight into the theory of disruptive technologies. In 2003, he wrote The Innovator's Solution, which gave practical examples as to how to make use of the theories put forth in his earlier book (Christensen 2003). The important concepts from his original book are summarised here.

Disruptive technological changes have occurred throughout history and can come in any form. Disruptive technological changes and disruptive innovations, as Christensen calls it in The Innovator's Solution, are what drives industries to the next phase and these can either make a company stronger or destroy a company.

A distinction between a disruptive technology and a sustaining technology is made in the Christensen book. While a disruptive technology is one that would eventually take over the mainstream market and becomes the dominant technology, and is both radically different from the present mainstream technology and has worse performance, a sustaining technology is one that introduces incremental improvements to the performance or quality of the existing technology. Sustaining technological changes are usually brought on by the incumbents or large firms of the existing market.

Sustaining technologies, on the other hand, may be radical while others are of an incremental nature. Sustaining technologies address the same market as the original product in that they improve upon the performance of the established product along the axis of performance that this market has always needed. Sustaining technologies are led by the incumbent firms of the market and they rarely fail in such ventures. New entrants addressing sustaining technologies are almost sure to fail here as the incumbents would always have the upper hand.

In his research of the computer hard disk industry, sustaining technological changes were often led and capitalized by large, existing firms such as the change from 3.5 inch diameter to 2.5 inch diameter disk drives. Although it was a new entrant, Prairietek, that announced the introduction of the 2.5 inch disk drive in 1989, it was Conner Peripherals, the leader in the 3.5 inch drive industry that transitioned smoothly from 3.5 to 2.5 inch disk drives. The performance attributes from 3.5 inch to 2. 5 inch disk drives such as weight, size etc. did not change, which meant that the market still valued most of the performance criteria set out by the 3.5 disk drives. This therefore meant that the 2.5 inch disk drive was a sustaining change to the earlier 3.5 inch disk drive[9]. However, when a disruptive change occurred, as was seen when the 8 inch diameter disk drive was replaced by the 5.25 inch diameter disk drives, success went to new entrants. Architectural innovation shrunk the size of disk drives from 8 to 5.25 inches. This disruptive change was characterised by the different performance parameters. In the 8 inch minicomputer industry, capacity, cost per megabyte and access time were important criteria, while in the new 5.25 inch market, size and weight were important attributes[10]. This shows that the performance dimensions in which the 8 inch and the 5.25 inch disk drives were measured differed. What was valued in the emerging market was not the same as what was valued in the existing market. The new entrants initially entered the market with their disruptive technology by addressing a different segment of the market as compared to the earlier technology. These were either new market disruptions or low-end disruptions. Gradually, as the disruptive technology developed, the new firms grew. Due to the sustaining innovations that let to the continued development of the disruptive technology, the new entrant was able to move up market to the market that was dominated by the much incumbent or large firm and to compete against the incumbent or large firms. Soon, the new entrant was

[9] Clayton Christensen (1997)," The Innovator's Dilemma", pg 21-22.
[10] Op. Cit. pg 15.

able to out-compete the incumbent and taking over the market share (Christensen 1997).

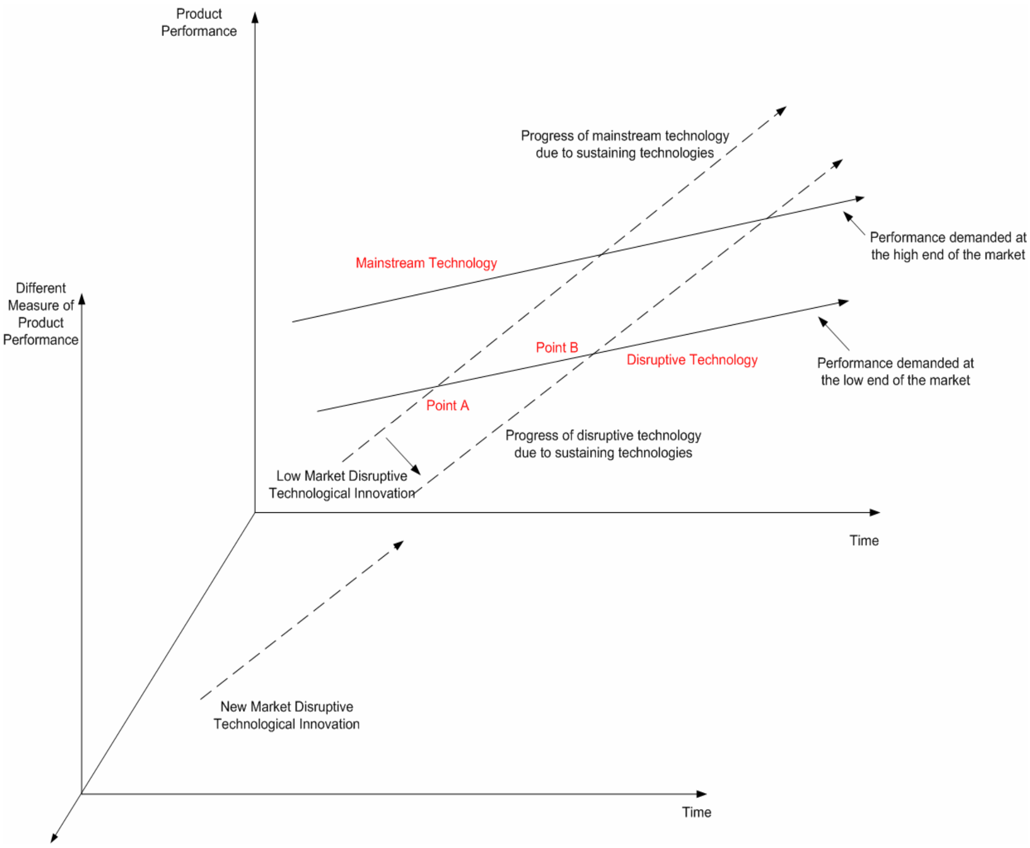


Figure 8. The impact of sustaining and disruptive technological change.
Source: (Christensen 1997) (Christensen 2003)

Figure 8 shows the impact of sustaining and disruptive technologies, as depicted in The Innovator's Dilemma (Christensen 1997). As characterized by these technology curves. It shows that after a point in time, the user's or customer's requirement for performance becomes lower than that provided by the original product (Point A). A disruptive technological innovation results in a new curve being added. This is because the performance of the disruptive technology is lower than that of the original technology and cannot be represented by the same curve. The low end disruptive technology will first be able to cater to the requirements of the low end of the market

(Point B) but as the technology improves, it is soon able to address the needs of the high end market as well. As the disruptive technology grows, it slowly starts to serve the needs of the high end market and is able to compete with the existing product. And this will continue until a new disruptive technology enters the market and the cycle is repeated.

A new market disruptive technological innovation is characterised by a separate graph which extends from the original market. Because new market disruptions address a market that has not existed before, and is based on performance characteristics that are different from the original technology market, it cannot be represented by the same market graph.

What all this shows is summarised here: It shows that a disruptive technology does not follow the same performance curve as the previous technology and it will first see to the needs of the low end market in its early days. At some point, the mainstream or existing technology will exceed the performance demanded by the low end market. This happens at Point A. Customers at the low end of the market have lower performance criteria this will be surpassed when the mainstream technology becomes too sophisticated and complicated due to sustaining technologies. With the introduction of a disruptive technology, a new technology demand curve is introduced. The needs of the low end market are not as rigorous as that of the high end market; their requirements can be fulfilled by the early development stages of disruptive technology. This is indicated by Point B. As the technology is developed further and performance is increased, the performance of the product soon surpasses what is required by the low end market customers. As the technology is improved upon further by sustaining technologies, it is able then able to meet the performance requirements of the high end market segment. When it meets the requirements of the mainstream technology, it is able to compete with the incumbent in this segment of the market. And because of the lower profit margins required by the disruptive technology, it will eventually out compete and displace the mainstream technology and take over this segment as the performance of the mainstream technology becomes too high even for the high end market.

The new market disruption is based on performance qualities that are different from the original product and is therefore represented by an extension of the original graph. The new market disruption develops in the new market where it addresses the needs of non-consumers or consumers who were not served by the original product. The challenge in a new market is not to compete with the incumbent but to compete against non-consumption (Christensen 2003). It therefore does not invade the incumbent’s market but pulls customers away from that market into a new one.

Disruptive technologies here are defined as ones that result in worse product performance in the near term and that bring to a market a very different value proposition than had been previously available. It is difficult to do any market analysis or studies on market requirements as there is no market to address. These address new markets where no prior knowledge is available. First mover advantages are significant in these emerging markets compared to later entrants and later entrants are not as successful. New entrants are small firms that do not have the extra baggage of having to keep satisfying current clients that the older, bigger firms in the market have to do. But it is often these new small entrants that cause the fall of the bigger firms. After having introduced the new disruptive product to the new market segment, slowly, the new entrant grows and soon gains a position in the mainstream market occupied by the older large firms. As this previous new entrant's size increases, it becomes more difficult for them to enter the even newer smaller markets that will some day become a large market. It is therefore difficult for firms to adapt to new markets once they become too big.

As mentioned earlier, there are two kinds of disruptions, namely low-end disruptions and new market disruptions. Low-end disruptions are those targeted at users who have been by-passed or overlooked by previous technologies that were too expensive or sophisticated. They occur when the rate at which a product or technology improves is higher than the rate at which customers can adapt to its new performance. At some point in time, as characterised by the technology curves diagram, the performance of the technology will exceed the needs of a particular market segment. It is at this point that if a disruptive technology enters the market, it would cater to this segment of the market that has been left behind by the previous technology. The disruptive technology will be of a lower performance than the previous technology bit which is adequate for the users that were left behind. New market disruptions are those targeted at new customers who were not previously served by the older product. It is when the technology is of poorer performance in almost all aspects and is only able to cater to a new or emerging market that was not served by the previous technology. New markets are different from low end markets because new markets have nothing to compare the disruption to while low end markets have the previous technology as a comparison. However, to the new entrant bring in the disruptive technology, both markets represent new unexploited revenue source that can be amassed with their disruptive technology. The main characteristics of an incumbent and a new market entrant are shown in Table 2.

Incumbent Company	New Market Entrant
Addresses old market	Addresses new (potential) market
Big profits	Lower profits
Existing processes in place	Not tied to any existing processes
A lot to lose if moves down market	Almost nothing to lose by starting down market.

Table 2. Differences between an incumbent and a new market entrant.

For simplicity, let us assume that the market is made up of an incumbent or large company and several new market entrants. While the incumbent has already built up its customer base from past dealings with clients, the new market entrants do not have any existing customer base leverage. Therefore, we can say that the incumbent addresses the old market while the new entrant addresses a new (and probably unformed) market. Big profits from its market would be the driving force of the incumbent company while a new entrant is able to work with low (initial) profits. The incumbent would have a fixed way of operating and of doing things and it would be difficult to change these processes while the new entrant is not tied to any existing process and is thus able to adapt in any way the market direction takes. Based on these, the incumbent would have a lot to lose if it decide to move downmarket (as a new disruptive technology would cause it to do) while a new entrant has very little to lose by addressing a new (non-existent) market.

The different concepts of disruptive and sustaining technologies may be illustrated in Figures 9 and 10. These two figures show the Technology S- curves, which were first used by Richard Foster to depict technological progression (Foster 1986). Sustaining technologies or innovations are a result of either incremental changes or radical changes. The incremental changes are seen from the individual S-curves as shown in Figure 9. Radical changes are jumps in technology, e.g. from Technology 1 to Technology 2. These are not disruptive changes because their performance is represented on the same graph making use of thee same product performance axis. Radical changes can result in either sustaining or disruptive changes. Each of the different technologies represented by the different S-curves are addressing the same market and with the performance criterions. The dotted line represents the progress of a firm through different technologies due to sustaining changes.

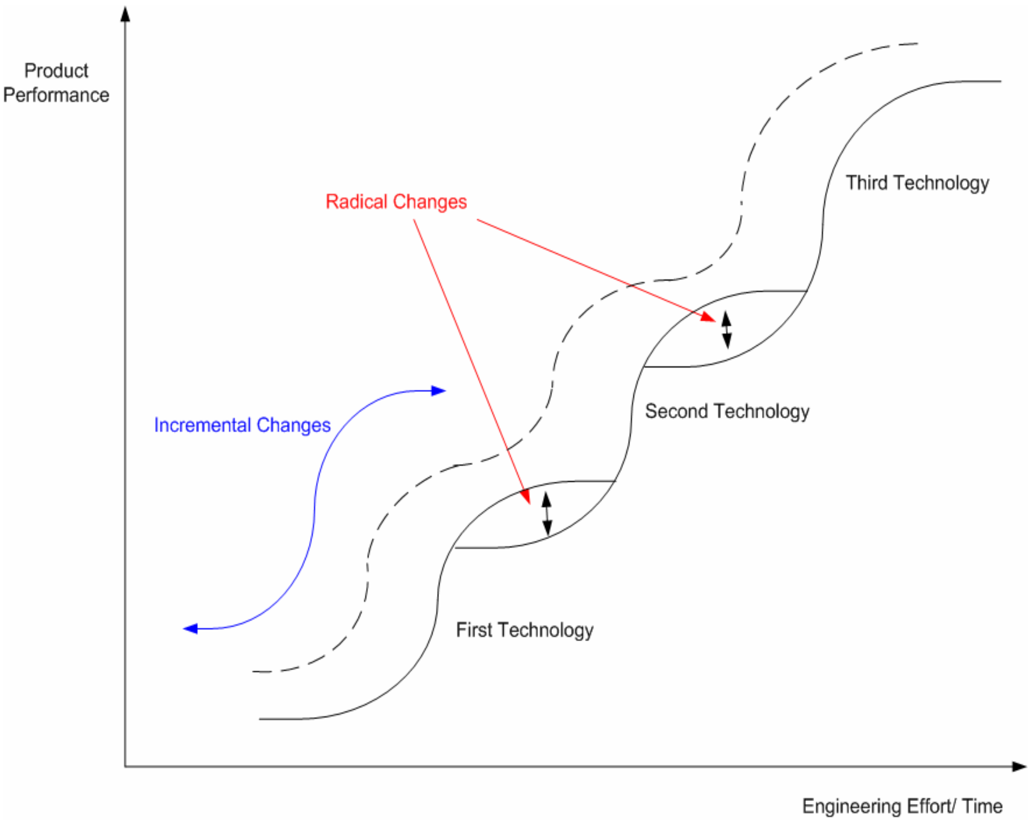


Figure 9. Technology S-curve for sustaining technologies
Source: Adapted from (Christensen 1997) and (Foster 1986).

However, disruptive technologies cannot be represented in the same way to that of sustaining technologies (Christensen 1997). This is shown in Figure 10. As disruptive technologies emerge, they are developed with no relation to the existing technology and with different performance criteria to the original product. Thus, a disruptive technology will have its own development trajectory. This trajectory is independent of the existing technology and so it cannot be represented on the same product performance axis as the original technology. This is because a disruptive technology is one that has different performance attributes compared to the mainstream technology. This will remain status quo until its development progresses to such an extent that it is able to satisfy the product performance attributes of the original market. The existing technology and the disruptive technology are initially said to be addressing two different value networks with different performance attributes. When the disruptive technology is able to meet the product performance of the mainstream product, it will then be able to compete in the existing product market. This is indicated by the red arrow in Figure 10. Technology 1, the existing technology, operates in the first value network, Market A. Technology 2, a disruptive technology based on a completely different performance criterion is introduced to Market B. As development on Technology 2 advances, its performance will be able to address that what is needed in Market A. This will result in Technology 2 occupying a space in Market A and subsequently competing with and taking over Technology 1's market.

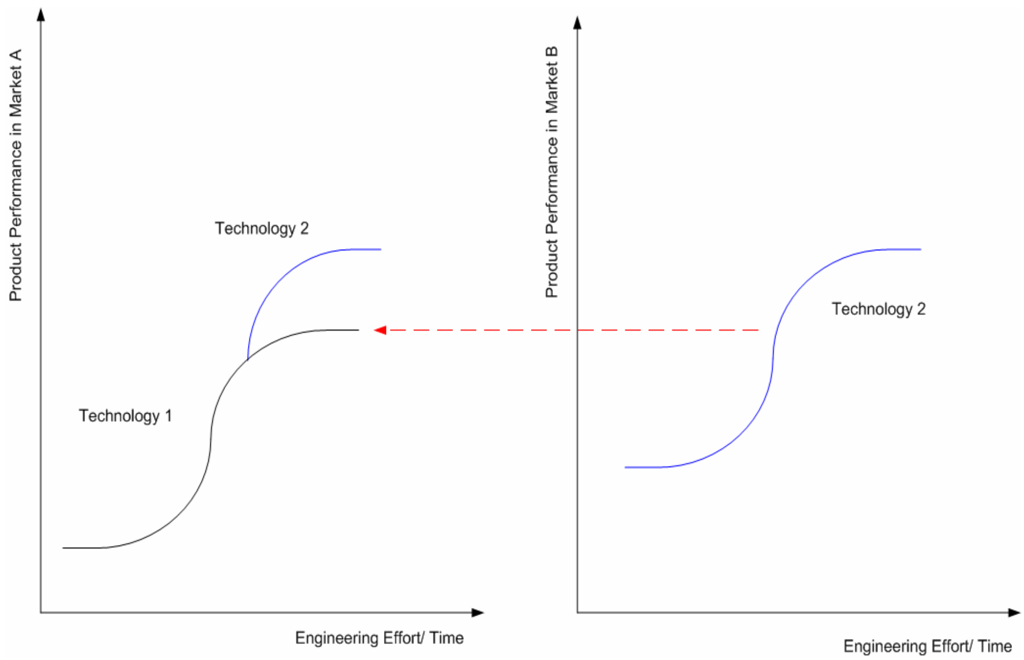


Figure 10. Technology S-curve for disruptive technologies
Source: Adapted from (Christensen 1997).

Christensen also states that large firms falter in the face of disruptive technologies not because of bad management but because management does precisely what they are supposed to: That is, to serve their biggest customers and work within their existing business model. However, the mistake that is made is that the actions of management are addressed to sustaining technologies and with the appearance of disruptive technologies, they are unable to use tried and tested methods used for analyzing sustaining technologies and this thus leads to failure of the firm getting a foothold in the new market. A firm that was once small and addressing a disruptive technology market and that grew into a large firm will find it very difficult to move down market to address the next disruptive technology. The new market would be too small and too unpredictable for a large firm and it is up to the new small firms to address this new market and to one day grow into yet another large firm. As the firm grew bigger, its business model changed to accommodate its new size and as it strives to operate in the bigger market, it loses its capability to operate in smaller, less established markets. As firms grow, the core competences and its associated business model changes and it becomes difficult to address smaller upcoming markets that the disruptive technology and the small entrant firm that is pursuing this would be able to address.

The inability of large firms to recognize until it is too late and to react to disruptive technologies earlier, as they are entering the industry is due not to the lack of know-how and technical capability but one of economics and market. Incumbents will always address the needs and requirements of their best customers. These customers are usually from the high end of the market and therefore demand higher performance and quality from the technology rather than low cost and lower performance. It is because these incumbents listen to their best customers and offer sustaining technologies to further better their technology, they fail to address the requirements of the other end of the market. The low end market represents but a fraction of the revenue that incumbents obtain from the high end market and therefore, in their eyes, not worth the effort. And whether there are new markets to address with lower performance technologies. Disruptive technologies target new smaller markets which are not attractive to the incumbents.

There is also mention of large firms that have tried to put their eggs in two baskets, by further developing the old technology and introducing a series of incremental innovations and by also establishing development work on the new disruptive technology. This method, however, has proven not to be very successful with most firms that have undertaken this.

2.2 Theories of Innovation

Although a disruptive technology is the essence of what causes an incumbent to fail and to exit the market, it is not only the original disruption that causes this. A disruptive technology, as discussed in the earlier section, is one that enters a different market to the existing technology as it is not able to compete with the performance of the existing product. However, incremental changes to the disruptive technology will enable it to develop in performance until it becomes possible for it to compete in the mainstream market of the original market.

A disruptive technology or innovation rarely becomes the dominant design in its own right. The dominant design is the culmination of the development of the disruption and this is what is seen by and accepted by the market. As seen earlier in Figure 8, when the disruptive technology is first introduced into the industry, it has a rather low product performance. Only with sustaining technological changes and incremental changes is it able to meet the needs the low end market segment and then to move up market into the high end market segment. The dominant product design therefore does occur from the disruptive innovation itself. It is the product of sustaining technologies worked upon the disruptive technology. It is only with improvements and development on the disruption that a dominant design will emerge (Utterback 1975). Therefore for a dominant design to occur, it is usually preceded by first a disruptive technological change, followed by several rounds of incremental and sustaining changes to the original disruption before a true dominant product design can occur. The product that is finally adopted by industry as the ‘standard’ and all firms will conform to this standard is the dominant product design.

In their research, Tushman and Anderson mention that each technology cycle starts with a technological discontinuity or a disruption (Anderson and Tushman1990). Each technological discontinuity will have its own life cycle or technology cycle where the advent of the discontinuity will produce an era of ferment (Anderson and Tushman 1990). At this point in the technology cycle, the industry is volatile and competition between the firms is strong. The era of ferment is characterised by continuous substitution as well as competition amongst the different designs that have been introduced by the many firms. The design competition results in a dominant design (Utterback 1975). This dominant design is the culmination of many design phases and it is this dominant design that will become the accepted market standard. The Tushman and Anderson technology life cycle is one that bears similarity to Christensen’s theory of technological disruption. Both sets of authors mention instability of the industry when a disruption or discontinuity occurs. Tushman and Anderson describe the life cycle of products while Christensen provides and insight into how a disruption may introduce differences into the product life cycle- such as the introduction of a new product. Tushman and Anderson look at this from more of a technology standpoint and how product innovation leads to process innovation. Christensen argues from a market standpoint and the effects of a disruption on a market point to the similarities of both views and relatedness that technology has on market and vice versa.

Two other important concepts that are introduced by Tushman and Anderson are that of competence enhancing and competence destroying. Product discontinuities that are competence enhancing are usually introduced by established firms or incumbents, because this type of discontinuities makes use of existing technological knowledge and therefore existing firms are more likely to succeed with this. On the other hand, product discontinuities that are competence destroying are usually introduced by new entrants. This is because the technologies in these products are new and established firms and incumbents are usually reluctant to adopt this new technology. Competence destroying product discontinuities are synonymous to disruptive technological changes while competence enhancing discontinuities bear a close resemblance to that of sustaining technological changes. Therefore, it leaves the new entrants to lead this disruption. Tushman and Anderson further state that dominant designs are always introduced by established firms or incumbents due to the fact that only these firms have the market knowledge to set a standard.

The concept of a dominant product was first introduced by Abernathy and Utterback in their paper "A dynamic Model of Process and Product Innovation" (Abernathy and Utterback 1975). Continuing from this paper, Utterback, in his book, "Mastering the dynamics of Innovation", describes how innovation will result in a dominant design (Abernathy and Utterback 1994). It is also mentioned that product innovation is often followed by process innovation, where the company concentrates on production of the product and improves upon the methods of production or the process of production. While a radical product innovation, as described by Christensen is called a disruptive change, a radical process innovation, as described by Utterback[11] is known as a discontinuous change. Both product and process innovation are closely linked and increases in one does affect the outcome of the other. By product innovation, we mean the actual product that is introduced to the market. Process innovation, however, refers to the steps and processes that go into the manufacture of the product.

[11] James M. Utterback, "Mastering the Dynamics of Innovation, Pg 135.

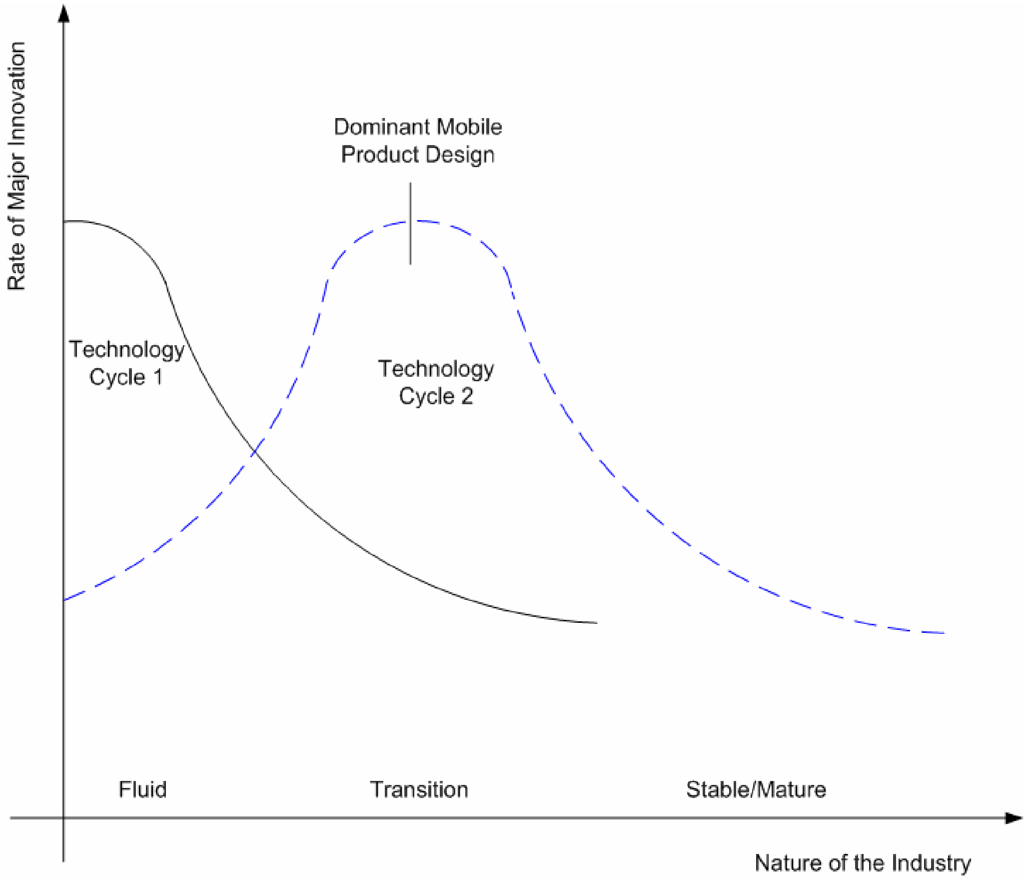


Figure 11. Rate of product innovation.
Source: (Abernathy and Utterback 1975) and (Utterback 1994).

Utterback mentions that it is often difficult to recognise a dominant design, except in retrospect (Utterback 1994). There are many ways in which a dominant design is determined:

1) By a chance event.
2) By something intrinsic in the technology that make it stand out.
3) By social and organisational factors[12].

[12] Op. Cit. Pg. 49.

Figure 11 shows the product life cycle as depicted by Abernathy and Utterback. This shows the rate of major innovation with time and the nature of the industry at as the product life cycle progresses. As Technology Cycle 1 comes to its matured stage, with a decreasing number of major innovations, a new Technology Cycle enters. Technology Cycle 2 is first made up of a massive amount of activity where many innovative products are introduced by many different firms in the industry, all vying to be the next dominant product. The radical innovations and number of major innovations ends when the dominant product emerges. This is characterised with a transitional nature of the industry where firms adopt the features of the dominant product and those that do not often have to leave the market. The rate of product innovation decreases after the dominant product emerges and only incremental changes to the dominant design will occur from now on. The industry will then reach a specific phase or a mature stage where little or no radical innovations will take place for this particular product. Utterback further mentions that somewhere along the product innovation curve, “the performance criteria that serve as a primary basis for competition changes from ill defined to uncertain to well articulated” (Utterback 1994). It is at this point that the new product or technology enters the fluid stage of the industry and competition towards the dominant design starts.

Process innovation, which refers to the processes used to produce the product are usually lagging that of product innovation. When product innovation is still in its fluid stage, the processes used to produce it are inefficient and unsophisticated. However, once the rate of major product innovation slows down, the rate of process innovation will increase and catch up, to a degree, to the expectations that is fitting to that of the product. All this point to the instability of the industry at the beginning of each life cycle, and the subsequent transitional phase that it goes through when striving towards the dominant design or dominant product. The emergence of the dominant design (be it product or process innovation) will then see a decline in the rate of major innovation to this process or product. After this, the industry will reach a stable or mature stage characterised by incremental changes to the product or process.

In 1972, Simon Kuznets said that the perspective that one adopts will determine whether an innovation is a process innovation or a product innovation (Kuznets 1972). He summarises that in process innovation, new machines and equipment in which the innovation is embodied are the norm, while at the same time, machinery and equipment are a product innovation in itself from the point of view of the firm that produces this product. This is almost paradoxical in its explanation but makes sense when considering either a process or product innovation.

Joseph Schumpeter may be seen to be one of the pioneers of evolution theory. Schumpeter’s notion of evolutionary analysis starts with a non-innovative state of economy. This stable state is perturbed when an irreversible disturbance that is the creation of an innovation is introduced. After this perturbation, a new non –innovative state is regained but in a new form (Schumpeter 1934) . In Schumpeter's terms, the evolutionary process consists in a sequence of the three steps. First stability, then an innovative change occurs, and finally a new level of equilibrium that is different from the original one is obtained (Andersen et al 1991). He stressed that technical progress is brought on by its discontinuous nature (Andersen et al 1991). In addition to technical progress (either product or process innovation), this also includes the emergence of new markets, the availability of new resources and raw materials, and also the structural reorganisation of a particular industry (Schumpeter 1934). Technical progress results in discontinuities of the past or disruptions of the past. Schumpeter also emphasised the concept of creative destruction which reflects the theory of economic evolution (Andersen et al 2004). This also fits into the concept of disruptive change quite nicely.

Innovation may be approached from different levels. It can be viewed and analysed from a macro, as well as on a micro level. While Schumpeter's theory of creative destruction looks at the industry level, which is in line with his view on the evolution of the capitalist economy; Christensen's theory is focused on a micro level and at the firm and the strategic decisions of managers. Although addressing disruptions at two very different levels, the theories do hold some similarities. The conclusion drawn by Christensen that good and successful companies often fail with the next wave of change because of the very management practices that have allowed them to become the market leaders; whereas Schumpeter's view is that of what happens when the economy is affected by a disturbance. These management practises that saw to the success of the dominant technology or product now make it very difficult for them to adopt the disruptive technologies. There is also the question of self-cannibalisation of their original market that companies are unwilling to do. They thus face the dilemma that what gave the company success will also cause it to fail. This conclusion was similarly drawn by Schumpeter in his economic theory, though on a different level of analysis. Christensen's conclusion is similar in thought to what Schumpeter concluded in that capitalism will fail because of its success (Zhang 2001).

2.3 Christensen Continued…

The term "disruptive technology" was used in Christensen's first book but he later adopted the term "disruptive innovation", which was used in his second book, "The Innovator's Solution". (Christensen 2003) This was probably done in line with the fact that not all disruptions need to be technology related; Disruptions could appear in other forms, such as disruptive products, services, business models and business strategies. Innovativeness not only exists in technological terms, but also in other parts that contribute to the success of a business and examples of innovativeness in business models and businesses also give rise to disruptive changes in the industry.

Therefore, disruptive innovations will result in completely new products or as a completely new way of producing a product or to distribute a product. A disruptive innovation can also result in a completely new way to provide services (Zhang 2001). The end result of sustaining innovations, on the other hand, could be incremental improvement to the performance of a product or to the performance of an organisation and its processes (Zhang 2001).

In the Innovator's Solution, Christensen re-iterates the difference between low-end and new market disruption, as well as the differences between a sustaining innovation and a disruptive innovation (Christensen 2003). Low end market customers are easier to identify than new market customers as these customers are the ones who have lost interest in the original product because it had become too sophisticated or complicated to use. In order to win business in the low end market, the new entrant will have to come up with a business model that "earns attractive returns at the discounted prices". On the other hand, new market customers will be more difficult to identify as the market for this group of users does not exist yet. When the new entrant is ready to introduce its product to the new market, it should first assess that the product is one of lower performance attributes compared to the original product. But the product should also have better performance in new attributes that were not important in the original product. All that, with the presence of a business model that would allow for lower profit margins and low prices per unit of product could see to the success of the new entrant in the new market.

To identify disruptive footholds is a difficult task and Christensen states that it is really a difficulty in obtaining the correct match between what the customer wants and what the company plans to do. Inability to identify or identifying the wrong footholds will probably lead to failure.

Something that was mentioned in his earlier book and again in this book is that of self-cannibalisation. Christensen states that incumbents will try everything they can in order to keep their current product in the market and intrinsic factors built in to the organisation prevent it from developing and introducing a new product that could disrupt the existing product (Christensen 1997). The incumbent's structure and policies does not look kindly upon potential disruptive technologies and this prevents it from adopting the disruptive technology. Managers are trained to look at producing results and do everything they know in order to sustain and increase the growth of their new product. It is not in their or the company's best interest to look at potential disruptions and to grow them. They are not trained to look at disruptions and to cannibalise sales of the current product. Also, it is just not the logical for them to take a technology that is aimed down market and to forego the high returns on their existing products.

An interesting thing that has been done by Christensen is to fit an innovation's requirements with the organisation's capabilities, as shown in figure 12. This framework allows managers to exploit capabilities within their current processes and values and to create new ones where this is lacking. This analysis will show managers where their organisation stands with respect to disruptive and sustaining technologies and to proceed from there- whether they can make use of the current organisational capabilities or to create and/or acquire new capabilities to launch a new growth business (a potential disruption). This diagram first appeared in the Innovator's Dilemma and was again discussed in the Innovator's Solution (Christensen 1997) (Christensen 2003).

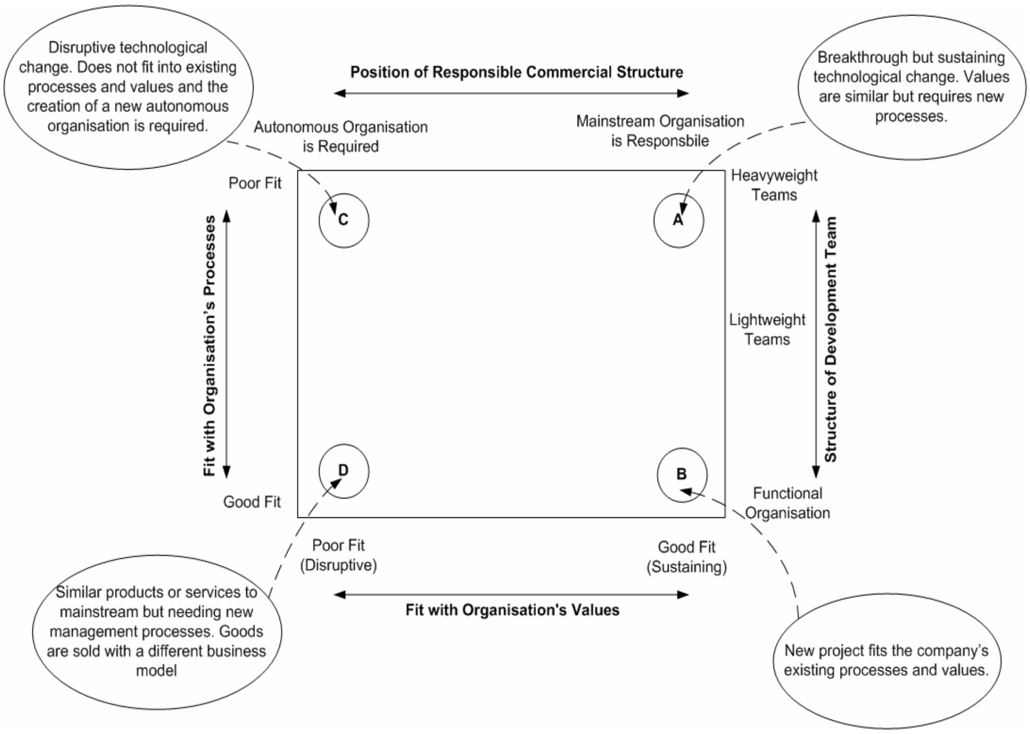


Figure 12. A framework for finding the right organisational structure and home. Source: (Christensen 1997) and (Christensen 2003)

According to this framework, the left axis measures the extent to which the existing processes currently used in the organisation will also be able to support the new job. The processes include those related to interaction, communication, coordination and decision making (Christensen 1997). The right axis represents the structure of the development team. Teams are functional, lightweight or heavyweight. Comparing both axes, functional and lightweight teams are therefore useful when exploiting the existing and organisational capabilities and processes. However, if the organisation's present capabilities and processes impede the work, then a heavyweight team will be required to create new processes and build new capabilities (Christensen 1997).

The lower horizontal axis represent whether the organisations existing values will fit into the new job's needs and requirements. If it does, then it means there is no need for a separate organisation to oversee its development and the new job may a part of the existing organisation (Christensen 1997).

Regions A, B, C and D represent the different positions that a company could be at any given point in time.

In Region A, the manager is faced with a breakthrough but sustaining technological change. It fits with the mainstream organisation's values because it is a sustaining innovation. However, because it is a breakthrough technology, it would require new types of interaction and coordination. It is a poor fit with the organisation's existing processes which means that new processes will have to be developed by a heavy weight team (Christensen 2003). This team will work towards the creation of new processes and therefore new capabilities.

Region B represents a product that is a good fit with the current organisation's values and processes and can be developed with ease within the existing organisation's structure (Christensen 2003). Co-ordination of such a project should fit well with a lightweight development team.

Region C represents the case when the manager is confronted with a disruptive product that neither fits into the organisation's values nor its processes. In this case, the manager should strongly consider establishing an autonomous organisation to grow the disruption. Differences in values can only be overcome when an independent company is used to launch the product. A different brand may also be needed. To undertake these big challenges, a heavyweight development team will most probably be required (Christensen 2003).

In Region D, the product would probably be something very similar to that produced currently by the company. It is a good fit with the organisation's processes and can therefore make use of current processes already in place in the mainstream company

(Christensen 2003). However, because this product is probably sold under lower cost business model, the values required are not in line with the mainstream company's practises.

The four regions therefore show that different technologies or innovations will need the managers to react differently. One has to be flexible and to adapt to the current situation at hand. A potential disruption will require the most work against the normal practices within the firm and would have to be handled carefully by the manager.

One interesting concept that is mentioned in the Innovator's Solution is interdependence versus modularity in the value chain. According to Christensen, interdependent architectures optimise performance in terms of functionality and reliability, while a modular interface is one that optimises flexibility, in which there are no unpredictable interdependencies across components or stages of the value chain. This concept has also been mentioned by Fleming and Sorenson in their paper "Navigating the Technology Landscape of Innovation". They mention that coupled or interdependent are riskier but are more likely to lead to breakthroughs (Fleming and Sorenson 2003). Companies that have been most successful in the beginning are those with optimised interdependent architectures. Later, disintegration occurs and the architectures and industry will move towards openness (Christensen 2003). In the beginning, when the functionality and reliability of a product are not good enough to satisfy the customer's needs, a company with proprietary architectures will enjoy success. However, as the product improves and competition becomes stronger, modular architectures and industry standards will be more successful. We see this in today's mobile industry. Device manufacturers such as Nokia and Motorola, which used to be proprietary owners of their own architectures, have, as competition increased and functionality in products became more abundant, adopted a modular and flexible approach. This is in line with what Christensen has argued here.

He stresses that managers should recognise that the best time to invest for growth to identify for growth is when the company is still growing and to do this, they should try to identify a possible disruptive foothold and to build on and develop this potential. The next step is to appoint a senior manager who is not afraid to do things differently and to make changes where no other is willing to do so. Thirdly, a team should be created and a process for shaping ideas must be made. It is one thing to think of innovative ideas but another to actually develop these. Finally, the team should be made aware of disruptive innovations and change and to know that these innovations are crucial to the survival of the firm. This is the Innovator's Solution.

2.4 Where the Loopholes Lie – Christensen's Critics

A disruptive technology is only that when it is viewed from a particular point of view: that of the company that is affected by this disruption. From other perspectives, this disruptive technology fails to be that. Even Christensen has mentioned the fact that the Internet is disruptive to some firms but sustaining to others. And it is really dependent on whether the disruption is in line with the firm's business model (Christensen 2003). But this of course raises the question a disruptive technology is in a disruption or whether it is disruptive only in the eyes of those involved? The perspective that one takes in viewing technological breakthroughs and whether to categorise it as a disruptive technology or as something else remains very much unanswered. The fact that a disruptive technology, as defined by Christensen, is one that addresses the needs of a different market to the that of the existing technology does not make it disruptive to this new market. So if we are to consider disruptive technologies from a market perspective, we are really talking about two different markets, at the initial development of the disruptive technology.

In his second book, the Innovator's Solution, Christensen has shown that a disturbance in the market may not only be due to a radical technology being introduced in the product. Market disruptions may occur due to innovative technologies. However, disruptions in the market may also occur to non technology related innovations such as innovative business models or business strategies. The term disruptive innovation covers all other innovations as well. When disruptive innovations include strategy and business models, it really becomes a whole new dimension to disruption studies. Many recent so-called disruptions have been due to innovative business models rather than innovative new technologies. Examples are low cost airlines and also internet PC shopping (such as DELL). Christensen sees the Internet as being a sustaining innovation for DELL, which made use of the Internet to sustain its sales[13]. However, others argue it is the innovativeness of the DELL business model which saw to its success. It may be a combination of both but this shows that success can be viewed as being two-fold - the result of a sustaining innovation on one hand and a disruptive innovative business model on the other hand. It may happen that between different industries, that a particular new technology may be disruptive in one is viewed as sustaining in another. This shows that disruption is a relative term and what is disruptive to one company might have a sustaining impact on another[14]. It should always be clear that when talking about disruptive technologies that one is talking about it happening in one industry.

Several critics of Christensen's theory have emerged since his first book was published. One of the main criticisms is of the ambiguity of terms. Daneels claimed

[13] Clayton Christensen (1997)," The Innovator's Dilemma", pg 41.
[14] Clayton Christensen (2003)," The Innovator's Solution", pg 193.

that Christensen had not been clear on several areas (Daneels 2004). The terms: disruptive technology, sustaining technology, discontinuous technology, and incremental technology have been used by many economists and techno-economists. Some have made use of these terms interchangeably and to refer to technology as well as industry and market. In this thesis, the terms: radical technology, incremental technology, disruptive change and sustaining change will be used as described in Section 2.5

Christensen's work mainly points intrinsically to the fact that first movers have the advantage when it comes to disruptive technologies (Christensen 1997) (Christensen 2003). However, with sustaining technologies, the incumbent will more often than not have the upper hand and new entrants bid to gain a position in the market of sustaining technologies will not succeed. Other researchers have, contrary to Christensen, said that copy-cats or imitators actually have more of an advantage than first movers (Schnaars 1994). In a later paper, Christensen too looks at the importance of timing of entry rather than being the first mover (Christensen 1998). This concept is not explored fully in the Christensen books but it should be noted that it is not all the time that first movers have the advantage. They may have a slight advantage but only if they use their position wisely.

The S-curves show discontinuities and also disruptions represented by only one technology. However, it is often that several new technologies vie with one another to take the place of the old technology in any market segment[15]. When a period of discontinuity happens, it is usually caused by more than just one innovation. There can be possibly more than two such innovations based on different or similar technologies hoping to disrupt the main market. The disruptors rarely succeed as individual attackers. When different potential disruptors show their wares and prepare to attack the market at somewhat the same time, there is more chance that the incumbent will fail. Therefore, the S-curve that has been analysed earlier should in reality include more than just one new product. Several S-curves exist probably exist at the time of disruption. One critique of the Christensen theory is therefore that he only looks at one possible potential disruptive technology but not the effects of having more than one potential disruptive technology in the same market segment.

There has not been enough mention that attackers fail more often than not compared to defenders. New entrants are faced with problems that can cause it to fail in the attack. Just as the incumbent has its problems, the new entrant too is faced with inherent problems that could cause it to fail in its attack of the incumbent's market. Christensen has mentioned the problems of the incumbent and what causes the incumbent to fail but he has not really touched on the new entrant's side of the story

[15] Richard Foster (1986), "Innovation: The Attacker's Advantage", pg 103.

and the problems that a new entrant has to face in disrupting the market. Richard Foster has mentioned a few (Foster 1986).

Contrary to what Christensen mentioned in that incumbent firms do not react to new entrants because they are unable to change they way they do things, recent studies have shown that firms, both incumbents and other large companies are more than willing to change and are ready to react in one way or other to the possible disruption caused by a new entrant or a new innovation. It is how they react that may be different. Incumbents will do almost anything to defend their market position while new entrants have nothing really to lose in trying to establish themselves in the new market. Charitou and Markides looked at the different responses that incumbents or leading companies had to a disruption (Charitou and Markides 2003). In addition to the conclusion from Christensen that companies should embrace the disruption and set up a separate division of the company, Charitou and Markides show that companies do in fact respond in several different ways. They mention 5 key different responses that companies will choose when confronted with a potential disruption (Charitou and Markides 2003). These are:

1) To focus and invest in the traditional business and focus on the existing business
2) Ignore the innovation as it is a addressing a totally different market and is no threat to its business
3) Attack back and disrupt the disruption by emphasizing even newer product or service attributes
4) Adopt the innovation by playing two different and conflicting games at once
5) Embrace the innovation completely, scale it up and grow it into the mass market.

Christensen mentions that incumbents listen too much to their users and that it is because of listening too much that leads to their failures. Other researches in user involvement and adoption have come to different conclusion and they do not agree that listening to the users would cause the company's failure. One set of researchers is that of Glen L. Urban and Eric von Hippel whose paper "Lead User Analyses for the Development of New Industrial Products" makes use of a lead user concept where the market will most likely take to what a lead user's chosen product (Urban and von Hippel 1988). User involvement in his studies plays a big importance in the development of products by companies. This implies that companies do need to listen to their users in order to address their requirements properly. The mention of lead users that further exemplifies how the user and the technology curve are interrelated is mentioned in Geoffrey A. Moore's "Crossing the Chasm" (Moore 1998) Here, it is mentioned that on the technology curve, there are different regions of the curve where different types of users will be involved in product usage and that one of the biggest challenges lies in getting the lead users and early users to accept the product and thus propelling the product to the mainstream product line. And therefore it is good to listen to at least some of your users. To cross this invisible line between technology adopters and other general users, companies will have to find out from the early users what it is that would allow them to do so.

2.5 A New Outlook of Disruptive Technologies

Disruptive technologies or disruptive innovations are indeed those that bring to the market a very different product offering and often at a much lower cost. But how difficult is it to really classify products and technologies as being disruptive. In many if not all cases, it is only possible to do this on hindsight and when the market has already been established.

The definitions that are found in most innovation theory overlap and this can be quite confusing if one cross-reads different authors on similar, but not identical areas. To avoid confusion, some of the more frequently used definitions in this thesis will be discussed here and applied throughout this thesis.

Incremental Innovation versus Radical Innovation:
An incremental innovation is viewed here as one that has small additional technology added to the existing product, which results in a new product. Incremental innovations are those with similar attributes to the existing product but with additional features or add-ons that make it different in some small way to the existing product. A radical innovation on the other hand is one that is based on a different set of technology or on an entirely new technology to produce. The technology used in the making of a radical innovation is both new and novel to the industry. Incremental and radical technological changes or innovations can be the outcome of architectural innovation, modular innovations which are purely technological advances. In both cases, incremental and radical innovations refer to the technological inputs that result in a new product.

Sustaining Change versus Disruptive Change:
A sustaining change is one that continues the lifespan of the existing product and is the result of some change in the technology. The change in technology may be radical or incremental in nature. A disruptive change is one that sees to the beginning of a new product and the end of the existing product. It is usually the result of a radical change in technology. When referring to sustaining and disruptive changes, we are usually looking them from a market point of view, and the result of some technological innovation that has already taken place. A sustaining or disruptive change does not refer to the technological inputs in the product.

Although there are many merits to the Christensen's theory, it is believed that further development and clarification could also be brought forth. The suggestion here is to include another plane of analysis in order to make the theory more operational.

Incremental or radical technological changes will not directly result in a market disruption or the market being sustained. Incremental or radical technologies will result in either a substitute or a complement product, which in turn will, according to a company's strategy, be either sustaining or disruptive.

In the Christensen theory on disruptive technologies, two sets of concepts are introduced: Incremental vs. radical technologies or innovations and sustaining vs. disruptive changes. The first set of concepts is related to the technology solutions as such, while the analysis as to whether a technology innovation is sustaining or disruptive is a market issue, i.e. related to a discussion on whether incumbent operators find it profitable to explore the new technology options. Furthermore, Christensen makes the point that a radical innovation does not have to be disruptive. A technology innovation may be radical but still in line with the existing products of incumbent companies. One can, therefore, not from the degree of 'radicalism' determine whether it will be a disruptive or sustaining innovation.

This has led to many analyses and suggestions – following the theory of Christensen – regarding the disruptive nature of different technologies. In these analyses, technology innovations are 'confronted' with the term disruptiveness, and if they are seen to be sufficiently radical, they are deemed to be disruptive. However, often when adding a market analysis, it turns out that these supposedly disruptive technologies are implemented in the product portfolios of incumbent companies – which are supposed to be the hallmark of sustaining technologies. It seems that a link is missing between the concepts of incremental vs. radical technologies or innovations and sustaining vs. disruptive changes. This link is here suggested to be the concepts of complementarity versus substitution (Tan and Henten 2005).

Figure 13 shows the possible relations that could result in a disruptive or a sustaining technology change. As technological changes first and foremost involve technology, it must first be established if the technology innovation is incremental or radical. An incremental innovation is one that is reliant on the existing technology and builds upon it. A radical innovation, on the other hand, is defined as one that makes use of new, different technology to the existing one to produce an innovative product. While incremental innovations are almost progressive or a step up from the existing technology, a radical innovation breaks away from the existing technology and starts a different progress path. Incremental innovations more often than not will result in complementary products.

Looking at the technologies that exist in the mobile world today, one could quite possibly label these technologies as incremental or radical. Radical innovations will result in products with improved performance in different criteria from present products. Radical innovations are most likely to result in substitute products. This is mainly due to the conclusion drawn that radical innovations are likely to be competitive to the original products. It is only with radical technological innovations that substitution of the original is possible. Radical innovations may also result in complementarity. In this form, a radical innovation was adopted as a complement and used in harmony with the existing product. This is a strategy that the company involved chooses. Rather than compete with the existing product, the company chooses to address the radical technology as a complementary product. However, more often than not, a radical innovation is more likely to result in a substitute product than a complement. A radical innovation in this sense creates competition to the existing technology and competes as a substitute because the company involved has chosen to address the radical innovation as a competitor and possible substitute rather than a complementary product. This stance puts the company more on the offensive. A substitute product, however, may not necessarily be disruptive to the market. It could also lead to a sustaining change. But most often, substitute technologies will lead to market disruptions.

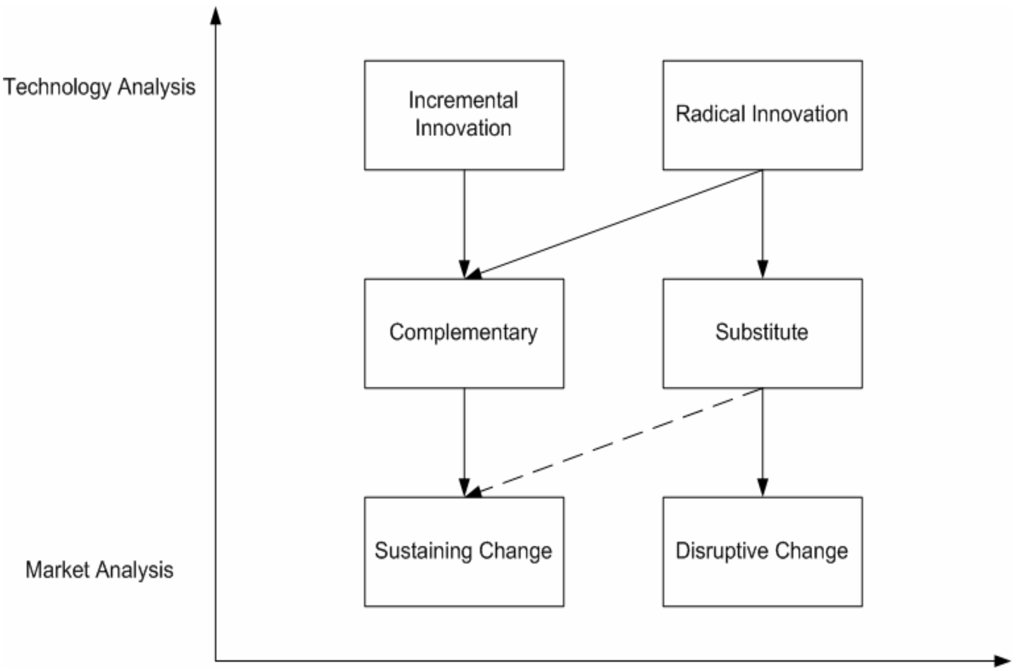


Figure 13. How technology innovation results in disruptive or sustaining changes.
Source: (Tan and Henten 2005)

Porter mentioned that Schumpeter's "creative destruction" characterised technological change as one in which monopolies were destroyed and new industries were created and that technology can change the rules of competition easily (Porter 1983). Creative destruction will lead to the business (firm) changing its character (Link and Siegel 2003). It is difficult or impossible to forecast and estimate. Technological change came in different stages: Invention, innovation, diffusion and imitation. A distinction between innovation and invention may be made by associating newness with invention and usefulness with innovation.

This was of course analysed in a macro-economic level where the industry was subject to change because of new technologies. Christensen, on the other hand, has developed a somewhat more micro-economic level theory with his theory of disruptive technologies, whereby he looks at how individual companies react to changes in technology. Although both Schumpeter's theory and Christensen's theory overlap, they do refer to different aspects of the economy. The Christensen's theory is perhaps more suitable on an individual company level while Schumpeter's theory is more for the economy or industry as a whole. In many aspects, they are related but it should be pointed out that fundamental differences exist.

Rosenberg suggested that a lot of Schumpeter work has dealt with the substitution side of new technologies but not much has dealt with the equally important side of complementarity that exist between new technologies (Rosenberg 1976). Complementarity and substitutability are two side of the same coin. These possible sides of new technologies are something that may be considered before the market decides on whether a change is going to be sustaining or disruptive. Technology changes can be either incremental or radical in nature, as depicted in Figure 13. But changes in technology can then be viewed as either being complementary or a substitution to the existing technology. When this has been decided by firms, then only will the technology be categorised as either sustaining or disruptive in the market.

The issue of whether of technology being a substitute or a complement has also been looked at by Olli Martikainen in his paper, "Complementarities creating Substitutes". Here, he suggests here that "competitive disruptions occur when there is asymmetric competitive convergence" (Martikainen 2005). He makes use of the examples of the mobile phone and the lap top computer, with the mobile phone moving from a region of mobility towards a region of increasing processing capacity and the laptop computer moving from a region of processing capacity towards a region of mobility. With this, he meant that a product in one region could increase its utility towards the other region, such as from mobility to increase in processing capacity and vice versa. All this means that goods that are complementary in one sense could become substitutes as they converge in that region of utility.

The fact that disruptive technologies lead to new markets has caused much interest in industries throughout the years. Whether a technology becomes a sustaining one or a disruptive one really depends very much on individual firms and their reactions to these technologies. One could say that the whole point of the theory on disruptiveness is to empower company executives in their strategic approaches to new technologies. The purpose is not, as it is most often used, to put ‘labels’ on technologies regarding their sustainability of disruptiveness. The strategy of a firm in coping with new emerging technologies will steer them towards a disruption or a sustaining change. It is never easy to look at a set of different upcoming technologies or innovations and to decide which of them will be sustaining and which of them will be disruptive to the existing market. When a firm faces a new technology, it often has the means to react to it, either to treat it as a threat or to treat it as something that would be complementary to its current technology. And, if the new technology proves to be disruptive to them, it is probably because they did not foresee the consequences of their business strategy and, therefore, failed to react to the emerging technology when it first appeared. This could then be interpreted as a market disruption. But on the other hand, if the strategy had been to adopt and to see the technology as a complement or as one that could work with (instead of against) the existing technology, then the technology could likely be sustaining to the existing market. A technology only becomes a market disruption if a threatened firm does not change its strategy to encompass the new technology.

In his book, Christensen mentions that one of the strategies a company could choose would be to locate the department dealing with the potential disruptive technology in a separate location to the headquarter, so that the culture and existing processes of the firm would not hold back the development of the potential disruptive technology. An alternative could be to create a spin-off company that would develop its competencies for the disruptive technology outside the jurisdiction of the original company. However, there are many mobile network operators that have reacted differently to that by incorporating WiFi technology into their suite of services. These companies have chosen to integrate WiFi into their existing technology portfolio rather than to set up separate companies or departments. One of the things that have probably propelled them to do so is to make use of existing resources, such as manpower, planning know-how and other logistical resources. Additionally, there is also the possibility of developing co-marketing strategies and to offer bundled services. As a complement, it was then introduced to the market as a supplement to their mobile network. WiFi was adopted as a sustaining technology that could complement their mobile technology network and was not viewed as a threat or as a substitute to their mobile network.

A disruptive technology is, therefore, one that is not characterised by technological attributes but by its impact to the market. With Mobile Fi only just being specified and WiMAX being rather new to the wireless and mobile markets and equipment and devices for WiMAX only just beginning to enter the market, WiFi will be analysed in a case study (in Section 6.10).

A disruptive technology is probably the outcome of a substitute product which is probably the outcome of a radical innovation or technology. But it is how the company incorporates this new technology into their existing market that counts. The adoption of a new technology is not easy and it has to be decided within the company's strategy whether to bring the new technology under its existing company structure or to create a separate company or affiliate that will look into the new technology. When making this decision, different outcomes will result if the technology is considered a complementary product or if it is considered a potential substitute to the existing technology that the company is dealing with.

2.6 Discussion

The theory of disruptive technology is an interesting innovation concept that has captured the attention of academics and strategists in business for some time. It is possible to find examples of this theory in different industries, as theorised by Christensen. In this thesis, Christensen's theory has been used as a basis for the analysis but not it is noted here that the theory should not be the taken as the final word in disruptive technology analysis. Although his theory does indeed provide a good framework to which to start out, it does not cover all angles of innovation nor does it prove beyond all reasonable doubt to be what happens in industry. The examples given are realistic. But, this is only so when his it is viewed from one perspective. When viewed from another perspective, the theory is not as sound as it seems. It should be made clear at this juncture that Christensen's theory has been used as a point of departure as it provides a good foundation or framework with which to develop upon. One of the possible ways to further develop this theory has been discussed earlier. Though not complete, the Christensen theory does give a good background and insight into the fundamentals of disruptions and it also provides the building blocks with which to work and improve upon.

Christensen's theory of disruptive innovations fits in to the general study of innovation and put chronologically, is the continuation of what was started by Schumpeter and then taken up by Rosenberg. The general theory states that disruptions occur in industries because of radical change in technology and leads to some firms (incumbents) leaving the industry and new firms (new entrants) entering the industry. This has been observed by Schumpeter in his "creative destruction" and with Rosenberg and also with Christensen. Therefore, the theory does have some good standing. The theory also fits in nicely with work done by other Innovation researchers and has therefore been taken to be a basis for analysis as discussed earlier.

As much as the theory has been used and as much as it fits into other work in Innovation Economics, there have been critics of Christensen. Some feel that the theory is not developed enough. Others feel that the way the theory has been applied has been rather subjective. The theory of disruptive innovation as proposed by Christensen does lack certain aspects that could be further analysed. One of these things has been proposed and that is the addition of another plane of study to make the transition form technology to market smoother and to give the analyses a more strategic feel. The transition between technology innovation to market disruption or sustainability requires another plane which will make the transition more operational. The strategy analysis of technology change to market change is a result of whether companies view the technology as one which is complementary to their existing product or whether it is a substitute to their existing product. The strategies of companies will depend on how they are able to classify the technology or innovation and this will then lead to a market disruption or sustainability.

The different strategies of companies will choose in reaction to the new technology or innovation will result in differing business models and finally in different outcomes. The theory of disruptive technology or innovation is therefore one that may play a large part in the development of business strategy and therefore the development of business model in companies.

3 Today's Different Technology Platforms

Today's mobile and wireless industries are a plethora of different types of technologies. The different technologies have varying performance criteria and different target users. However, some of them seem to be competing against one another while others are said to be complementary to others.

This chapter describes the different wireless and mobile platforms that are available today. It does not give a full technical specification of each of the standards but points out the important features and enhancement possibilities of each of the different technologies. These features and enhancements provide examples of incremental changes that are made to products or product designs in order to increase the performance of the original product. A user making use of a mobile or wireless service will expect certain features, based on past experiences. There are several features that are part of the basic expectation of the users. Different current technologies will contain these features to different degrees. Newer technologies will have to match or exceed the current technology performance.

As new technologies enter the market, the features are either compatible with or enhance the present technologies already available or they are radically different and provide some different choice to users. The features that describe a new mobile technology are generally characterised by (but not limited to) the following criteria:

1) Data rates
2) Quality of service
3) Coverage
4) Mobility
5) User experience (including points 1 to 4)
6) Cost

One of the features that new technologies have to offer is that of higher data rates when it comes to data services. As the complexity of data services increases and more bandwidth intensive applications are made available to users, data rates (and also bandwidth) will have to be enhanced to cater to them. The spectral efficiency quantifies the data rate that can be transmitted and received within a given bandwidth. However, this depends not only on the bandwidth, but on other factors such as the transmitter power, interference and noise.

As we enter a heterogeneous network environment with different access types, one feature that must not change is the quality of service. If there is any change of quality of service, it must be ensured by the network operator(s) that it is not noticeable to users.

Good coverage is something that mobile operators have worked very hard to achieve. Wireless technologies still do not have the coverage offered by mobile technologies and are therefore at a disadvantage in this criterion. This feature is in intrinsic expectation of users and will therefore count as one of the basic features users look for.

Mobility is the obvious goal of mobile technologies- allowing users to communicate with the freedom of movement. This is the fundamental feature of mobile technologies. It seems to be the trend that newer wireless technologies are attempting to compete against mobile technologies. But before this can be fulfilled, the mobility criterion has to be matched, and as we see, this is currently underway.

An improvement of the overall user experience, including the earlier mentioned features will be an important characteristic of mobile and wireless technologies to come.

The technologies that have been chosen and described in this chapter have different features that make then enhancements or incremental advancements of present day technology; or they offer new and different technological features that could lead to disruptive changes in the market.

Using UMTS-WCDMA as a starting point, the following technologies will be looked at in terms of how they have affected the market and how they could affect the market. To present a well-rounded discussion on technology analysis, both present day technologies and also possible technologies of the future will be looked at. Different assessments of each technology in terms of their effect on the market will be discussed. The technologies looked at in this chapter have been chosen to show that each of the different features mentioned earlier may result in both sustaining changes as well as disruptive changes. Technologies such as CDMA2000 1x EV-DO is seen as a contemporary to UMTS. The two technologies have been seen to develop at the same time. The two technologies have similar performance and companies backing each have viewed the other as a competitor, thereby leading to the potential disruptiveness of the other to its market. In terms of features such as data rates, mobility, coverage and quality of service, UMTS-WCDMA and CDMA2000 1x EV-DO would appear to be mostly comparable.

The categories of wireless technologies and mobile technologies are to separate the different types of access technologies. The gap is ever closing with wireless technologies gaining mobility in the future. The two other categories seen in this table include current technologies and future technologies. Current technologies refer to ones that are already established in the market and have working examples. Future technologies are in the developing stages and are generally not introduced into the market in the current time.

EDGE is seen as an enhancement of GSM-GPRS. As one of the paths to UMTS, EDGE is looked at because it has only slightly lower performance compared to UMTS, in terms of speed and thereby user experience. EDGE is an incremental technological advancement to GSM-GPRS but some operators have come to view EDGE as an alternative to UMTS. Although EDGE has not proved to be very popular in Europe, it does present an alternative to UMTS, and thereby presenting a potential disruption to UMTS.

The enhancement possibilities of the different technologies are mentioned here to provide example of how incremental changes occur quite frequently in the mobile industry. Incremental changes have been characterised by improvements on the existing technology or product and no radical changes are introduced. Some of the technologies mentioned in this chapter have been improved on in some ways; and these will be used to show the evolution of technologies. The descriptions of technologies here will be referred to in the coming chapters.

Table 3 shows the different type of access networks. The network types have been classified according to their range or coverage. WAN networks provide the largest coverage and are made up of mobile technologies. MAN networks provide somewhat less overage than their WAN counterparts and consist of newer wireless technologies such as WiMAX and Mobile-Fi. These technologies have the potential of being mobile and are considered by some to be potential substitutes to current mobile standards. LANs provide smaller coverage and are meant as wire or cable replacements. A PAN is made up of very short range technologies for an area around the user.

Wide Area Networks (WANs) cover the widest area and examples of these networks are GSM, CDMA 2000 1x and WCDMA. These networks offer mobility but with data rates that are not as attractive as some others.

Metropolitan Area Network (MANs) on the other hand offer less coverage, compared to WAN technologies but somewhat higher speeds. Mobility is slightly reduced to mobile networks of WANs. They are often referred to as being in between WANs and LANs and their coverage areas do overlap (Stallings 2001).

Local Area Networks (LANs) cover smaller areas, typically that of offices or buildings. WiFi is the best example of a wireless LAN technology that exists today.

Personal Area Networks (PANs) are short range networking technologies that allow connectivity between different equipment, e.g. Laptop and mobile phone. Ad-hoc and sensor networks are also classified as PANs as they are developed with short range, high data rates in mind.

All the different networks will probably be inter-connected and inter-operable in the future. This is to ensure that the user will get the best connectivity at any given time and at the least cost and would be the basis of a true heterogeneous network.

Type of Network	Technology	Range
WAN	GSM/GPRS/EDGE	35 km
	WCDMA (UMTS)	10 km
	CDMA2000 1X EV-DO	10 km
MAN	Mobile Fi (802.20)	15 km or more
	WiMAX (802.16)	56 km or 3 to 10km
LAN	WiFi (802.11)	~100 m
PAN	Bluetooth (802.15)	10s of metres
	UWB	10s of metres
	Ad-Hoc and Sensor Networks	short range

Table 3. Different mobile and wireless technologies.
Sources: (Stallings 2001), (NTIA 2000), (Lipset 2003), (Costa 2004), (NIST 2005), [8].

Technology is developing at a faster rate than is absorbed by users. The multitude of choices that we are now faced with in terms of network type, devices and services has grown much in the past few years. Different generations of mobile technology may exist at the same time. This improvement on the original product is what constitutes an incremental change. This and other types of changes are what make the mobile and wireless industry the way it is today.

3.1 WiFi, WiMAX, Mobile-Fi

The three wireless technologies: WiFi or WLAN, WiMAX and Mobile-Fi are of much interest today. WiFi has been in the wireless industry for sometime now while WiMAX products are only just starting to enter the industry. Mobile-Fi has not been developed quite as yet and it will therefore be awhile before we see more of this standard. These three standards are described in fuller detail here.

3.1.1 WiFi

WiFi or WLAN (Wireless Local Area Network) has been in the wireless world for some time. It started out as a wire replacement technology and was used in offices and schools to replace the many miles of cables that ran to connect LANs. Today, WLAN can be found in places as diverse as hotels, cafes and airports to petrol stations and homes. WLAN has become a standard technology and is incorporated into most laptops these days. The proliferation of WLAN and the popularity it has gained had initially caused some to see it as a threat to second and third generation mobile technology. After the initial excessive publicity surrounding it, WLAN is mostly viewed as a complementary technology to mobile technology as it addresses different requirements to that of mobile technology such as GSM or UMTS. WiFi has grown from being a LAN cable replacement technology to a public access means. WiFi has been termed to be complementary to 3G and other mobile standards. Firstly, the range of WiFi is not as wide as that of 3G, but it gives a much higher transmission rate than any mobile technology. Also, handoff between WiFi access points is still not possible and, therefore, it is known more as a wireless access possibility than a mobile technology.

WiFi is based on the IEEE 802.11 standard. Today the most widely used sections are the 802.11b and 802.11g. The popularity has also been increased by the fact that access points, routers and also pc cards are widely available and at a reasonable price. This has caused the wide deployment of WiFi hotspots by some operators.

We have seen WiFi deployment over the last years, privately in companies as well as homes, and also in public areas such as hotels, airports and cafes, providing easy access to the Internet. WiFi is a local area network technology that was originally thought to replace the thousands of miles of LAN cables that run across all offices, universities and homes. Instead of using a cable to connect to the local network, with WiFi, it is possible to connect wirelessly with the use of a wireless card on the PC and the network access point.

The 802.11b is still currently the most popular WiFi standard, giving transmission rates of up to 11Mbps. The newer 802.11g standard, which allows for transmission of up to 54Mbps, is gaining in popularity and is fully backward compatible with the earlier 802.11b version. 801.11g offers a higher bit rate due to its use of Orthogonal Frequency Division Multiplexing (OFDM) modulation. These two operate in the 2.4GHz frequency spectrum, which is unlicensed and may be affected by interference. The 802.11a standard operates in the 5.8GHz spectrum with a theoretical maximum transmission rate of 54Mbps.

With the 802.11r and 802.11s, the 802.11 community is preparing for a possible entry into the mobile market. With the increasing popularity of Voice over Internet Protocol

(VoIP), many see WiFi as one of the possible means of using VoIP with some form of mobility. VoIP mobile phones have already been introduced from Nokia and other device manufacturers. At the same time, Skype[16] will also be introducing services over 3G networks to make it available over all types of networks[17]. All these point to the popularity of VoIP services and applications. The IEEE 802.11r was established to ensure ease of use of wireless VoIP and other real time applications. WiFi quality generally degrades with distance to the access point. However, much also depends on the backhaul internet connection that is used beyond the access point. WiFi allows freedom from wires and quality is good enough that applications such as VoIP run acceptably well on WiFi.

The IEEE 802.11s for meshed WiFi networks will extend the coverage of WLAN networks. It does this by interconnecting nodes to allow data to be relayed from one node to the next and, by doing so, extending the coverage of a WiFi network. These two standards are extensions of the earlier 802.11x standards. When these two standards are implemented, they would provide a means for applications such as VoIP over WiFi to grow and these could potentially pose as a substitute technology to that of mobile technologies. With these developments, there is the further likelihood that new operators operating fully meshed WiFi networks would appear in the market and possibly compete against the mobile operators of today. On the other hand, there are certain other issues that have to be addressed before WiFi can really compete fully in the mobile market. Firstly, the power that is available from standard WiFi devices is somewhat limited and not suited for long range deployment. Secondly, security issues would have to be addressed further to give optimum protection to users.

WiFi is currently a wireless technology; however, mobility is being addressed. Costs of WiFi equipment have decreased over the years and are now generally affordable to most. The wide acceptance of WiFi by both industry and consumers and it remains to be seen how a mobile version of WiFi could potentially become a disruption to mainstream mobile technologies.

3.1.2 WiMAX

Work on the WiMAX (Wireless Interoperability for Microwave Access) or the IEEE 802.16 standard started in 1999. It is a broadband wireless access standard that was originally positioned as a complement to Wireless Fidelity (WiFi). While WiFi was seen mainly as a cable replacement technology for the numerous cables and wires required

[16] http://www.skype.com – cited 120905
[17] http://www.3g.co.uk/PR/Sept2005/1851.htm - cited 120905

for LAN connectivity, WiMAX was seen as more of a Metropolitan Area Network (MAN) technology providing a much larger coverage.

WiMAX, in fact, comes in two forms, a so called 'fixed WiMAX' and a 'mobile WiMAX'. Mobile WiMAX is a relatively new revision of the 802.16 rev.2004 standard and has been approved in December 2005 by the IEEE-SA Standards Board[18]. In 2004, 802.16 rev.2004 replaced the earlier 802.16a standard, which was the standard for fixed wireless access. The mobility option is of interest to many players in the mobile market although incompatibility between the 802.16 rev.2004 and 802.16e may deter some from deploying it. New potential operators see the 802.16e as a possible technology that could be deployed as an alternative to 3G networks. Existing 3G or other cellular network operators could see this as a potential threat or as a complement to their cellular product.

Currently, wire line operators find it increasingly expensive and not profitable to deploy fibre to far away office clusters and residential areas. WiMAX is seen as a possible alternative to expensive cable and fibre deployment. WiMAX, being a wireless broadband access standard, will be able to provide broadband services, on par with fibre or cable access. It is faster to deploy and less expensive than wire line deployments of fibre and cable and it also offers operators more flexibility in terms of deployment time frame and possible installation areas.

The initial 802.16 standard operates in the 10GHz - 66GHz frequency band and requires line of sight towers, but later revised version, the 802.16a extension uses the lower frequency of 2 - 11GHz and did not require line of sight (Gabriel 2003). It uses the licensed bands at 3.5GHz and 10.5GHz internationally and 2.5GHz - 2.7GHz in the US as well as the unlicensed 2.4GHz and 5.725GHz - 5.825GHz bands. In this case, operators do not have to obtain licences to operate in this frequency. 802.16 can operate at up to 124Mbps in the 28MHz channel (in 10-66GHz), while the 802.16a at 70Mbps in lower frequency, 2-11GHz spectrum (Gabriel 2003). The 802.16 rev.2004 standard should be able to achieve a throughput of up to 11Mbps[19] in the 3.5GHz spectrum (Thelander 2005). The 802.16a standard has been absorbed by the 802.16 rev2004 standard and today, this is the standard for fixed wireless WiMAX solutions.

The 802.16e standard addresses many different mobility issues that were previously not looked at; for instance, provision of connectivity to moving vehicles such as trains[20]. However, as mentioned earlier, the 802.16e standard is not compatible with the fixed 802.16 rev.2004. WiMAX, like WiFi, makes use of OFDM modulation techniques to increase efficiency and bit rate. The 802.16e standard makes use

[18] http://www.ieee802.org/16/pubs/P80216e.html - cited 060406
[19] Assuming that an outdoor antenna is used with a 3.5 MHz paired channel allocation.
[20] http://www.wi-fiplanet.com/tutorials/article.php/2236611 - cited 070105

Scalable OFDM Multiple Access (SOFDMA)[21] in which the number of OFDM tones increases depending on the quality of the signal for the particular user. OFDM will be looked at in more detail the Section 3.8.2.

WiMAX will initially be able to support Frequency Division Duplex (FDD) and Time Division Duplex (TDD) in the 3.5GHz and 5.8GHz bands (Gabriel 2003) (Thelander 2005). WiMAX does enjoy a considerable amount of industry support especially from Intel, which has already developed fixed wireless WiMAX equipment and have stated that they will develop silicon for premise equipment as well as notebooks as part of the Intel Centrino mobile technology when the 802.16e standard is ready. It is likely that the cost of equipment is will not be as low as that of WiFi and therefore not a consumer product but one that would be deployed by operators and such organisations. Products for the earlier version of WiMAX may not be as popular as the 802.16e mobile version of WiMAX which could be more useful for operators.

WiMAX has been marketed by its proponents as a cable replacement technology and also as last mile solutions to areas where it is expensive to deploy wired infrastructure. Its aim is to be an alternative to cable technologies such as ADSL or even fibre. In the less developed countries, it is unlikely that wired infrastructure is in place today. Therefore, if the economy permits and if demand exists, a possible alternative to wired technology is to use WiMAX. This is also the case for countries with rugged terrain and where it is not feasible to put in wired infrastructure. WiMAX presents a good alternative to this. The user experience is expected to be reasonable. However costs of deployment for operators will have to work into their economics. Initial cost of deployment is likely to be high compared to current WiFi prices. But if WiFi is any indication, then prices could gradually drop to more affordable levels making WiMAX a technology for the masses.

WiMAX development globally is very much in its infancy. Products are only beginning to appear in the market and some trial networks have been deployed, for example by Telabria in Kent in the UK[22] and solutions provider Danske Telecom in Denmark. WiMAX is still in its trial stages and full scale deployment has not occurred yet. However, because of the huge potential presented by WiMAX, many have predicted that it could become a disruption to mainstream mobile technologies.

A variation to WiMAX is that of Wireless Broadband (WiBro). WiBro is a South Korean wireless broadband initiative (Thelander 2005). WiBro licences have been awarded in Korea for operation in the 2.3GHz spectrum. WiBro is the Korean version of broadband wireless access that is set to be merged with the 802.16 standard in the

[21] http://www.intel.com/netcomms/columns/jimj105.htm - cited 090406
[22] http://www.theregister.co.uk/2004/11/04/telabria_WiMAX_kent/ - cited 120405

near future. WiBro services, which should deliver data speeds up to 1Mbps uplink and 3Mbps downlink and mobility up to 120 km per hour. Intel has shown its support for WiBro and reported it will make WiMAX/WiBro compatible chips in the future[23]. This is fundamental to achieving standardized products worldwide.

There are still several unanswered questions to the future development of WiMAX. One of these questions is whether to use the unlicensed spectrum or licensed spectrum below 11GHz or from 10GHz to 66GHz. Both have advantages and disadvantages and this also is indicative of the quality of service issues and costs of operations. Another question is how WiMAX can be used effectively in a world already filled with so many communication choices. The third question is how operators will react to WiMAX once cheap equipment and handsets become available. The final question for operators is whether to adopt the fixed wireless version first and then the mobile version, seeing that they are not compatible this may not be the best solution. It is difficult to predict the road that WiMAX will follow. But it is definitely worth following the progress it makes.

3.1.3 Mobile-Fi

Another broadband wireless access technology is Mobile-Fi or Mobile Broadband Wireless Access (MBWA), based on the IEEE 802.20 standard (Winters 2005a). This is the newest of the IEEE wireless standards and will operate in the licensed bands below 3.5GHz and have broadband Internet access speeds exceeding that of today's DSL and cable access options[24]. The 802.20 was introduced by the IEEE and its goal was to address the optimization of IP data transportation at over 1Mbps per user and in a mobile environment of up to 250km/h[25] (Winters 2005a).

Specifications for this standard are still in their early stages and it will take some time before this standard is fully ratified and so it remains to be seen if the 802.20 will take off in the mobile industry. However, even though Mobile-Fi is still in its early development stages, some people have come to view Mobile-Fi as a possible competitor to 3G because of its built-in mobility option that was planned from the beginning of its conception. If Mobile-Fi is able to support mobility of users as well as providing a broadband connection and with strong industry backing, it is likely that 3G and other mobile technologies will lose revenue to this technology in the future. It is thus worrying for all those parties involved in 3G deployment such as network operators and equipment manufacturers.

[23] http://www.ibiztoday.com/eng/articleviewer.html?art_id=50032&lang=eng – cited 160905
[24] http://www.pcworld.com/news/article/0,aid,116885,00.asp - cited 010905
[25] http://www.wi-fiplanet.com/tutorials/article.php/10724_3065261_4 - cited 170105

3.2 UMTS- WCDMA

In Europe, 3G generally means UMTS, and the UMTS air interface is comprised of two access modes, one of which is FDD mode. This is also called WCDMA. CDMA has its origins as a military transmission scheme which uses unique spreading codes to spread the baseband data before transmission. The signal is then transmitted in a channel, which is below noise level. At the receiver, a correlator is used to despread the wanted signal, which is then passed through a narrow bandpass filter. Unwanted signals will not be despread and will thus not pass through the filter[26]. WCDMA is one of the standards under the IMT-2000 umbrella for 3rd Generation networks. WCDMA is based on CDMA (Code Division Multiple Access) technology. UMTS provides mobile coverage, much like 2nd Generation GSM. Today, it has around 68 million users but this is gradually increasing, as more users switch from 2nd Generation to 3rd Generation mobile services [2].

WCDMA uses Direct Sequence spreading, where spreading process is done by directly combining the baseband information to high chip rate binary code. The Spreading Factor is the ratio of the chips (UMTS = 3.84Mchips/s) to baseband information rate.

WCDMA operates with paired spectrum, making use of 2 x 5 MHz carriers. Frequency bands used in FDD are 1920 to 1980 MHz Uplink and 2110 to 2170 Downlink (Schiller 2003). Some parameters of WCDMA are provided in Table 4 below.

Parameters	
Carrier Spacing	5MHz
Downlink RF Channel Structure	Direct Spread
Chip rate	3.84Mchips per second
Data Modulation	QPSK (Downlink) BPSK (Uplink)
Theoretical Maximum Data Rates	384Kbps (Outdoors) 2Mbps (Indoors)

Table 4. WCDMA parameters
Source: (Prasad 2000)

Efficient use of the available spectrum means that users must be able to share a 5MHz range and to transmit and receive at the same time. WCDMA uses orthogonal spreading codes which are unique to each user and hence ensuring interference is kept to a minimum. Only the matching spreading code is able to de-spread the data and retrieve the original data.

[26] http://www.umtsworld.com/technology/cdmabasics.htm - cited 210406

Enhancements to WCDMA are already in progress. Two such enhancements are HSDPA and HSUPA[27]. HSDPA introduces a new higher-order modulation format and this and some feature improvements would result in higher downlink data speeds. HSDPA would theoretically increase the transmission rate of current download services to around 2-3Mbps.This is seen as a much needed improvement over the existing 384Kbps with WCDMA. HSDPA is only applied on the downlink part. HSUPA is applied on the uplink part. Like HSDPA, HSUPA will give an increase in transmission speed in the uplink section.

After some initial teething problems with handovers and handoffs, the user experience of UMTS has slowly increased. Data services are more stable today and this offers better speeds compared to GSM-GPRS. Costs of UMTS licences as well as high costs of equipment have seen to a relatively tame roll-out of UMTS networks. Because UMTS was rolled out in built-up areas initially, mobile coverage in less populated areas was still through GSM. This meant that operators had to ensure handover between the two networks went seamlessly and thereby ensuring similar quality of service for users who go from GSM to UMTS or vice versa.

3.3 CDMA2000 1X EV-DO

CDMA2000 1x is a CDMA technology. It therefore has a CDMA background, like WCDMA. CDMA2000 1x-EV is a 3G technology and is optimized for packet data services. CDMA2000 1xEV-DO Rev0 provides a peak data rate of 2.4Mbps within one 1.25MHz CDMA band. It offers up to 153kbps transmission rate in the uplink. The 1x refers to CDMA2000 implementation within the existing spectrum allocations for CDMAOne - 1.25MHz carriers. This technology was originally proposed as one of the IMT-2000 standards by Qualcomm and is used in the Americas, Asia, and Eastern Europe and even in Africa. An enhancement to the Rev0 standard is the RevA. This would allow for downlink rates of up to 3.1Mbps and uplink rates of 1.8Mbps.

CDMA2000 1X EV-DO has been especially popular in Japan and Korea; and also in the Americas. Because most of the CDMA2000 1X EV-DO networks have been deployed by existing CDMAOne operators, the upgrade would consist of implementing and integrating an overlay packet switched core network. (Saugstrup and Henten 2004). This in turn limits upgrade costs for CDMAOne operators.

When CDMA2000 evolves beyond 1x, it will be referred to as CDMA2000 1xEV. 1xEV will be divided into two steps: 1xEV-DO (1x Evolution Data Only) and 1xEV-DV (1x

[27] http://www.4g.co.uk/PR2004/March2005/2050.htm - cited 130206

Evolution Data and Voice). CDMA2000 1x EV-DO is optimized for very high speeds in its first phase of operation. In its second phase, integrated voice and data rates of up to 3.09Mbps will be achievable. In its second phase, EV-DV will have similar performance to that of EV-DO RevA.

1xEV-DO uses a separate carrier for data, but this carrier will be able to hand-off to a 1x carrier if simultaneous voice and data services are needed. The allocation of a separate carrier for data services enables operators to deliver peak data rates of 2.4Mbps[28].

Chip manufacturers are working on producing multi-mode chipsets that are able to support the most popular types of network globally: GSM, CDMA 2000 and WCDMA. Chips able to support CDMA2000 and WCDMA networks are already available in the Korean market where both these types of networks are found. The difficulty in producing multi-mode chips and handsets will determine the level of inter-connectivity and inter-operability amongst the different technology platforms found around the world.

3.4 EDGE

GSM is still very much alive and well. With the number of users surpassing the 1.7 billion [29] mark, the uptake of GSM handsets is still growing, especially in the developing countries. One enhancement to the GSM network is EDGE, which cannot exist on its own but must work with or be added on to the GPRS network. When EDGE is used with GPRS, the maximum theoretical bit rate is 473.6 kbps (CDMA Development Group 2003). For each time slot, GPRS can handle a maximum of 20 kbps while EDGE can handle up to 59.2 kbps (CDMA Development Group 2003). However, in real world situations, the maximum rate is much lower and some networks have average bit rates ranging from 75kpbs to 135Kbps [30] (CDMA Development Group 2003).

With GSM, the modulation scheme chosen was that of Gaussian Minimum Shift Keying (GMSK), which is the most efficient mode of frequency shift keying[31]. It sends only 1 bit per symbol and thus is not as sensitive to noise and interference from the surroundings. With EDGE, the bit rate is 3 times more than that of GSM. And the modulation scheme used here is known as 8-PSK or 8- Phase Shift Keying. With 8-PSK, 3 bits are sent per symbol. Therefore, we see a 3 times increase in the bit rate,

[28] http://www.cdg.org/technology/3g/advantages_cdma2000_1x.asp - cited 270406
[29] http://www.gsmworld.com/index.shtml - cited 270406
[30] http://www.cingular.com/about/latest_news/03_06_30 - cited 150905
[31] http://gsm.argospress.com/gaussiminimushiftykeiin.htm - cited 280605

but with noise and interference becoming more of a problem because of the increase of phases and decrease in distance between them (Rønn et. al. 2003).

Enhancements to EDGE are known more broadly under the GERAN name. GERAN stands for GPRS/EDGE Radio Access Network and one of the items on its agenda is that of integration with UMTS[32]. EDGE Phase 2 is currently underway and it is part of an ongoing effort to keep GSM alive and to provide the possibility of higher data rates without having to move onto a totally new network such as UMTS. It has been introduced to see to the integration of GERAN with other networks with different core networks[33]. EDGE has, on a whole, not been as popular as some of the other technologies but it remains a possible alternative to UMTS.

Seen from GSM, EDGE does provide improver user experience due to the increase in average bit rages. Coverage by EDGE is also almost the same as that of a GSM-GPRS network and therefore users will enjoy almost the same coverage as they had with GSM-GPRS. Cost of EDGE implementation is much less to deploying a full UMTS-WCDMA network, as it is purely and add-on to the GSM-GPRS network, and is an attractive cost-efficient alternative to going directly from GSM to UMTS.

3.5 Wireless Ad-hoc Networks

Wireless ad-hoc networks have become popular research topic in recent years. Ad-hoc networks are defined as wireless, self-organising systems formed by co-operating nodes within communication of one another that form temporary networks[34]. A multi-hop network is formed and connected in a decentralised way. Their topology is dynamic, decentralised, ever changing and the nodes may move around arbitrarily. The nodes are connected wirelessly and therefore subject to fading, noise and interference, just as in other wireless communication systems. The national Institute for Standards and technologies states that there are two main types of wireless ad-hoc networks: mobile ad-hoc networks and smart sensor networks [10].

Wireless ad-hoc networks are part of PANs, offering only short range coverage. The main costs of smart sensor networks are due to the tags or transmitters. Once costs decreases sufficiently, the idea or sensor networks may catch on quickly as their applications areas range from supermarkets to airports to even cars and weather sensors.

[32] http://www.3gpp.org/tb/GERAN/GERAN.htm - cited 160905
[33] http://dessr2m.adm-eu.uvsq.fr/presentation_edge.pdf - cited 160905
[34] http://fismat.umich.mx/adhocnow/ - cited 280705

3.5.1 Mobile Ad-hoc Networks

These types of network and network design are still being developed but the main idea behind ad-hoc networks is that it would be deployable in situations where other telecommunications infrastructure have been destroyed or are unavailable, e.g. in an earthquake area or terrorist attack situations. Military, emergency operations and disaster relief are just some of the areas that can make use of mobile ad-hoc networks to overcome the problem of lack of fixed or centralised communication systems.

Figure 14 illustrates and ad-hoc network formation. In a mobile ad-hoc network, no base stations are required and the network will be constructed without a wired backbone network. It will consist only of secondary wireless units allowing communication to pass through them. The concept of a distributed network is used here as there is no primary or secondary node. All the nodes have the same functions and data is transmitted directly from node to node to give end- to- end communication. Because of the dynamic nature of the ad-hoc network, resilient and efficient routing protocols are required. This also means that the network resources have to be managed carefully. Routing of packets efficiently becomes an important consideration in all networks, but especially so in a mobile ad-hoc network. It is difficult to design efficient network protocols for mobile ad-hoc networks as there are many more factors to consider compared to a fixed network and a centralised network. In a decentralised networking environment, there are many technical issues to solve including path loss, multi-user interference, topological changes and link quality. Design issues are more complicated so as to take into account parameters that are important for the dynamism and the adaptability of the network.

If and when these design and implementation issues are solved, the attractiveness of a wireless ad-hoc network lies in the fact that the network is able to change actively with the mobility of its nodes. There is no one fixed structure to the network and it can consist of more or fewer number of nodes in varying distances from one another at any given time. As mentioned earlier, these types of network will be useful in situations where other communication infrastructure is unavailable.

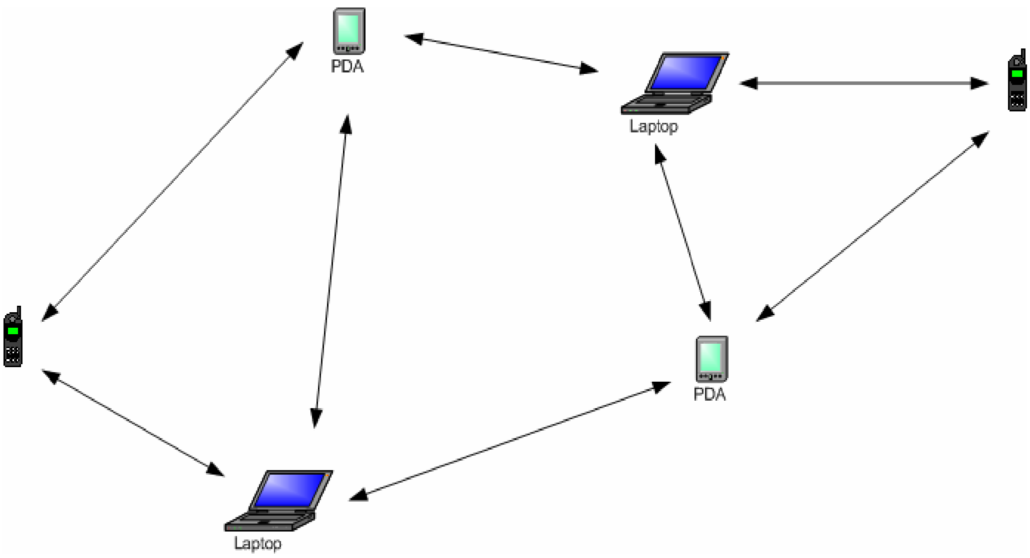


Figure 14. Mobile Ad-hoc network configuration
Source: (Tan Sep. 2004)

3.5.2 Smart Sensor Networks

Smart sensor networks are made up of a number of sensors spread across a geographically localised area [10]. These sensors are used to monitor or detect certain phenomena at different locations. Examples include changes in temperature or levels of pollutants. Usually, each sensor is intended to be physically small and inexpensive, thus making it possible to produce and deploy them in large numbers. A sensor is equipped with a radio transceiver, a small microcontroller, and an energy source, usually a battery and a signal processor. The main difference between sensor networks and mobile ad-hoc networks is that with sensor networks, the nodes have to detect or collect some form of data and not just communicate.

One of the important considerations for sensor networks is the battery life of each sensor. Since each sensor is expected to be small in size, it will have to be very energy efficient and to last a long time. The sensors will need to have self-organising capabilities. As the sensors or nodes will probably be spread out over a geographical area, it means that the nodes will have to have some sort of self-organising capability in order to communicate with other nodes and to reconfigure themselves whenever required. These sensors will have simple wireless communication capability and at least some low level intelligence for networking and signal processing purposes to allow the nodes to communicate and to process data obtained. Also, the ad-hoc nature and location of sensors makes it necessary for them to organise and network themselves and to adapt to different situations (e.g. when a sensor stops working because of low battery). Nodes will probably be able to communicate and to exchange or tabulate data with one another and there may be one master node that will have a longer range communication capability. Resilient network protocols and adaptive and robust wireless networking will be important in sensor networks.

One smart sensor technology that has been quite popular recently is that of Radio Frequency Identification (RFID). RFID basically make use of radio waves to identify people or objects automatically and offer transmission rates of up to 115 kbps (Schiller 2003). The most common identification method is the use of a serial number. Other information can also be stored on the microchip, such as medical records, for patients. An antenna is attached to the microchip and this which enables transmission of data to a reader. Collectively, this is the RFID tag (Negash 2004).

There are several types of RFIDs[35]:

1) low frequency RFID tags in animal identification
2) high frequency RFID tags in library books, building access control and baggage tracking
3) Ultra High Frequency (UHF) tags in commercial pallet and container tracking and in truck and trailer tracking in shipping yards.
4) Microwave RFID tags in long range access control for vehicles and road payment systems

RFIDs are already being used. But their costs are still not low enough for them to be used and deployed on a larger scale. Another concern with RFIDs is that of standardisation by vendors supplying both tags and readers. In Japan and Korea[36], RFIDs are catching on as mobile operators there have introduced mobile payment services.

Both mobile ad-hoc networks and smart sensor networks will make use of both presently available technology but will also make use of technology that is yet unavailable in the market today. The combination of several types of networking and communication technologies will be required in the successful deployment of mobile ad-hoc networks and smart sensor networks.

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[35] http://en.wikipedia.org/wiki/RFID - cited 140905
[36] http://today.reuters.co.uk/news/newsArticle.aspx?type=technologyNews&storyID=2005-09-13T080627Z_01_HO329184_RTRIDST_0_TECH-TELECOMS-SUMMIT-ASIA-WALLET-DC.XML – cited 140905

3.6 UWB (Ultra Wideband)

UWB is a part of the IEEE 802.15 standard, looking at Wireless PANs [12]. UWB technology makes use of very low power and is able to transmit digital data over a wide spectrum of frequency bands. A UWB transmitter works by sending billions of pulses across a very wide spectrum of frequency several GHz in bandwidth. The corresponding receiver then translates the pulses into data by listening for a familiar pulse sequence sent by the transmitter[37]. Therefore, synchronisation between the receiver and sender must be very precise (Schiller 2003). The IEEE 802.15.3 is the standard for high data rate Wireless PAN designed with QoS for real time distribution of multimedia content. The IEEE 802.15.3a is the amendment to this and aims to provide in excess of 100Mbps at a 10m distance and 480Mbps at 2m [13]. In a short distance, it means that fast data transfer of media files between servers and playing devices are possible.

Standardisation of UWB is being undertaken by the UWB Forum as well as the Multi-Band OFDM Alliance (MBOA) [13] [14]. The UWB Forum is concentrating efforts on increasing the performance with less complexity and at lower prices and lower power consumption. The MBOA alliance is looking at band-hopping OFDM solutions for high data rates UWB PANs. Multi-Band Orthogonal Frequency Division Multiplexing (MB-OFDM) is a new possible modulation scheme supported by the Common Signalling Mode (CSM) introduced by the UWB Forum.

There are several advantages to using UWB that make it attractive to further develop this technology. These are:

1) Low cost
2) High data rates
3) Low power consumption
4) Less interference compared with narrow band radio design
5) Low probability if detection
6) No Rayleigh fading[38] (due to its wideband nature)
7) Good multipath immunity

A potential use for UWB is in home multimedia networks supporting multiple devices in PANs. Another use is that of precise location identification and distance measurements [13]. It would also be possible to integrate UWB with WLAN, thus

[37] http://www.intel.com/technology/comms/uwb/download/wireless_pb.pdf - cited 040406
[38] In telecommunication, multipath is the propagation phenomenon that results in radio signals' reaching the receiving antenna by two or more paths. Causes of multipath include atmospheric ducting, ionospheric reflection and refraction, and reflection from terrestrial objects, such as mountains and buildings. Rayleigh fading is the statistical model for the effect of a propagation environment (due to multipath) of a radio signal.

giving WLAN more technical enhancements to today's version. While Bluetooth is probably going to remain the de-facto standard for lower data-rate needs[39], there was a move to merge research and development work in UWB and Bluetooth[40].

3.7 DMB (Digital Multimedia Broadcast) and DVB-H (Digital Video Broadcast- Handheld)

DMB is the process of broadcasting multimedia over the Internet, satellites or terrestrial links to be tuned in by multimedia receivers or players capable of playing back the multi-media program. DMB makes use a multi-cast process and in so doing, is able to send a single program to thousands of receivers (Lyoo 2004). The DMB standard is optimized for multimedia content. DMB is based on the Eureka 147 standard used earlier in Digital Audio Broadcast (DAB)[41]. South Korea and Japan have actively adopted this standard into their mobile service offering while trials have been taking place in Munich, Germany[42]

There are two forms of DMB: Satellite DMB (S-DMB) and Terrestrial DMB (T-DMB). In South Korea, there is predicted competition between the two DMB standards. S-DMB will make use of the 2.6GHz band while T-DMB makes use of the much lower 170 to 240 MHz band (Kim 2003). S-DMB makes use of expensive gap fillers to provide coverage to areas that do not have a line of sight view with the satellite transmission. Gap fillers will be used to fill the gaps in coverage and relay transmission signals like areas. This will ensure that users are able to receive the signal no matter where they are. Gap fillers are easy to deploy and are considered low cost equipment in 3GPP (Martin et al Sep 2002).This and the costs of maintaining the satellite and base station add to higher overall costs to that of T-DMB.

In Korea, while S-DMB is a country wide operation, T-DMB will offer regional services only[43]. This is because satellite coverage is much larger than that of terrestrial broadcast. Although both seem similar to end users, they are different in that satellite DMB is based on videos beamed from a communication satellite while terrestrial DMB operates on over-the-air signals[44].

DVB-H, which is a competing standard to DMB is based on DVB-T and is optimised for handheld devices. The DVB Project first started work on DVB-H to address the

[39] http://www.internetnews.com/wireless/article.php/3502726 - cited 270406
[40] http://informationweek.com/story/showArticle.jhtml?articleID=162101443 – cited 270406
[41] http://www.commsday.com.au/marketconvergence.pdf - cited 090905
[42] http://www.worlddab.org/latest.aspx - cited 090905
[43] http://www.telecomasia.net/telecomasia/article/articleDetail.jsp?id=158158 – cited 090905
[44] http://www.asiamedia.ucla.edu/article.asp?parentid=25933 – cited 090905

issue of battery life which would be one of the main requirements in mobile devices. Power saving is done by time slicing such that the receiver is only switched on in those time intervals when channel of interest is being viewed[45]. The receiver is turned off for the rest of the time. Both DVB-H and DMB have the same methods of Forward Error Correction (FEC) but DMB uses time- interleaving which makes it more robust in mobile environments. DVB-H trials have taken place and are continuing to take place in Berlin, Germany, Helsinki, Finland and in Pittsburgh in the USA[46].

Therefore, we see that DMB is being backed heavily by the Asian countries like Japan and Korea and these countries are seen to the most advanced in mobile technology. While DMB was designed from the start to work in a mobile environment, it has taken a lot more work to make DVB-H more power efficient and robust in a mobile environment.

There are ongoing questions as to whether DMB or DVB-H will compete with UMTS. This is quite likely, given the fact that with DVB-H (and DMB) the one-to-many effect of broadcast gives much more efficient use of bandwidth. With UMTS, video transmission must be multiplied by number of transmissions, thus consuming more bandwidth in the network[47]. DVB-H (and DMB) is therefore more efficient and more economical compared to UMTS broadcast. In the best case scenario, the two will complement each other, but for now, there are no plans for compatibility between the UMTS and the future DVB-H[48].

3.8 What is 4G?

4G or beyond 3G are communication technologies that will come after 3rd Generation systems. It has been defined as being Wireless Wide Area Network (WWAN) communications systems yielding high data-rates reaching 20Mbps to 40Mbps and which are suitable for high-speed multimedia, smooth streaming video, universal access, and portability across all types of devices.[49] Initial deployments are anticipated in Japan around 2010[50].

It has been difficult to really define what 4G or beyond 3G really is. Many see 4G as being the combination higher data rates and ubiquitous networking, where a user is

45 http://www.vdldiffusion.com/angl/product/dab/dmb.php - citer 090905
46 http://www.dvb.org/documents/white-papers/wp07.DVB-H.final.pdf - cited 0909095
47 http://www.journaldunet.com/0503/050308dvbh.shtml - cited 150905
48 IBID – cited 150905
49 Definition from http://whatis.techtarget.com/definition/0,,sid9_gci749934,00.html and http://www.netmotionwireless.com/resource/glossary_popup.asp - cited 010805
50 http://www.4g.co.uk/PR2004/March2005/2048.htm - cited 040406

able to make use of any of a multitude of mobile and wireless technology for access to the network. However, 4G is also many other things. It is the culmination of various different technologies in different areas making communication faster, cheaper and more efficient. 4G is probably best described as being a combination of (at least some of) the following attributes.

1) higher data rates
2) High speed multimedia
3) Ubiquitous access and networking
4) Interactive
5) Personalised and intuitive

These attributes will be made possible with the advancement of different technologies. Some of those that may be crucial to the development and success of 4G are mentioned here. These technologies are currently being developed and could play a large part in what 4G will be.

3.8.1 Multiple Input Multiple Output (MIMO) Antenna Technology

MIMO antennas are a type of smart antennas which use multiple antennas at both the receiver and the transmitter. These are separated spatially and make use of multi-path propagation[51] to increase throughput and/or to reduce bit error rates (Edinger et al 2004). Multi-path propagation occurs when a signal takes different paths when propagating from a source node to a destination node[52]. The MIMO systems has been one of the proposed solutions to increase the spectral efficiency while fulfilling the data rate required by the future wireless services (Negash 2004). Information theory has shown that with multi-path propagation, multiple antennas at both the transmitter and the receiver can establish essentially multiple parallel channels that operate simultaneously on the same frequency band and at the same time (Negash 2004).

With smart antennas, there are two types of gains: Antenna gain and diversity gain. Antenna gain is the increased average output Signal to Noise Ratio (SNR) with these multiple antennas. Diversity gain is the decreased required receive SNR for a given Bit Error Rate (BER) averaged over the fading channel (Winter 2005a).

Several MIMO techniques are available and make use of different approaches to antenna and signal optimisation. Selection diversity is one of these approaches and makes use of multiple antennas with overlapping coverage to select the antenna with the highest received signal power to mitigate fading (Winters 2005b). The second

[51] Definition from http://en.wikipedia.org/wiki/MIMO - cited 010805
[52] http://www.wi-fiplanet.com/tutorials/article.php/1121691 - cited 190405

technique is a switched multi-beam antenna which makes use of an array antenna with multiple fixed beams pointing at different directions such that the receiver picks the beam with the highest SNR (Winters 2005b). A third technique is with the use of an adaptive array whereby signals that are received by each antenna are weighted and combined to improve the output signal performance (Winters 2005b). One last interesting technique is that of MIMO with spatial multiplexing (MIMO-SM). MIMO-SM makes use of the receiver to combine all the received signals to get the signal from the first transmit antenna, with all other signals being interferers. This is done with each antenna to obtain all the signals (Winters 2005b).

MIMO techniques are already being used in some base stations but can also be used in other systems to increase their efficiency. WiFi devices and WiMAX devices will both reap advantages from using MIMO techniques, as will RFIDs and UWB. MIMO techniques may also be used in conjunction with OFDM. MIMO techniques promise a significant boost in performance for OFDM systems (Stüber et al 2004). One area where will be part of the IEEE 802.11n WLAN high throughput standard. This standard is still being worked on today and is expected to be ready in 2007 (Winters 2005b).

3.8.2 Orthogonal Frequency Division Multiplexing (OFDM)

OFDM is a type of communications technique known as multi-carrier modulation scheme. It makes use of multiple carrier signals at different frequencies, sending some of the bits on each channel. That is to say, the signal is split into multiple smaller sub-signals and these are the simultaneously transmitted over different frequencies to the receiver[53].

In a conventional multi-carrier modulation system, the total frequency band is divided into N non-overlapping frequency sub-channels or sub-carriers. Each sub-channel is modulated with a separate symbol and then the N sub-channels are frequency-multiplexed and transmitted. To eliminate Inter-Symbol Interference (ISI), channels do not overlap spectrally. This is so in a conventional multi-carrier modulation system. In an OFDM system however, overlapping sub-channels are used to increase the efficiency of spectrum usage (Prasad 1998) (Schiller 2003) (Stallings 2001).

In OFDM, the total frequency band is divided into a number of equally spaced frequency sub-carriers or frequency sub-channels. Separate symbols are then modulated into each sub-carrier. A sub-carrier or tone (frequency) is then used to carry a portion of the user information. The sub-carriers are then combined or frequency multiplexed (using Inverse Fourier Transform). This results in the time domain waveform being transmitted. Each sub-carrier is orthogonal or independent

[53] http://www.webopedia.com/TERM/O/OFDM.html - cited 200405

from the other (International Engineering Consortium).The sub-carriers possess the minimum frequency separation needed to have orthogonality in the time domain but the signal spectra overlaps in the frequency domain. This overlap reduces the average amount of spectrum required. Therefore the available bandwidth is being efficiently used. Because OFDM is able to modulate data onto separate sub-carriers, it is a modulation technique. OFDM is also considered a multiple access technique because different users may be assigned individual tones or group of tones and thereby allowing for efficient bandwidth sharing (International Engineering Consortium). OFDM is also known as multi-tone modulation. Figure 15 below illustrates the tones or subcarriers of an OFDM channel

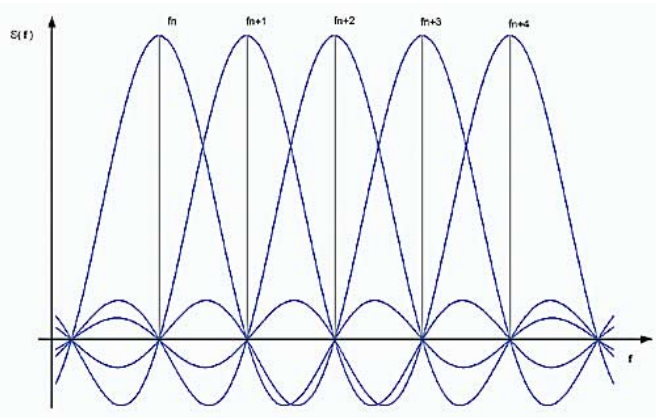

Figure 15. Frequency response of the OFDM sub-carriers.
Source: [15]

OFDM promises much efficiency in spectrum usage and has been adopted in several wireless standards. It has several advantages, the most important of which is its efficient use of available bandwidth by using overlapping sub-channels (Prasad 1998). OFDM has thus been adopted in several wireless standards including digital audio broadcasting (DAB), digital video broadcasting- Terrestrial (DVB-T), WiFi (IEEE 802.11a) and WiMAX (IEEE 802.16a) standard. It is also being considered in Mobile-Fi (EEE802.20a). This standard is still not very defined but it includes specifications for high bandwidth connections in moving vehicles such as trains and cars (Stüber et al 2004). OFDM is therefore considered to play a significant role in 4G development. There are several adaptations to OFDM that can increase the use of bandwidth and thereby improving the user's experience.

3.8.3 Variable Spreading Factor- Orthogonal Frequency and Code Division Multiplexing (VSF-OFCDM)

VSF-OFCDM is a wireless access scheme proposed by NTT-DoCoMo as part of their 4G development (Larson 2003). With VSF-OFCDM, information symbols are first spread by a CDMA codeword. Each chip of the resultant sequence is allocated to the successive OFCDM symbols in the time domain and to the successive subcarriers in the frequency domain. These are known as time domain spreading and frequency domain spreading. This is the main concept behind VSF-OFCDM: the two dimensional spreading of symbols (Acharya 2005). This is illustrated in Figure 16. This figure shows how one data symbol is spread in time with a spread factor of 4 and in frequency with a spread fact or of 2.

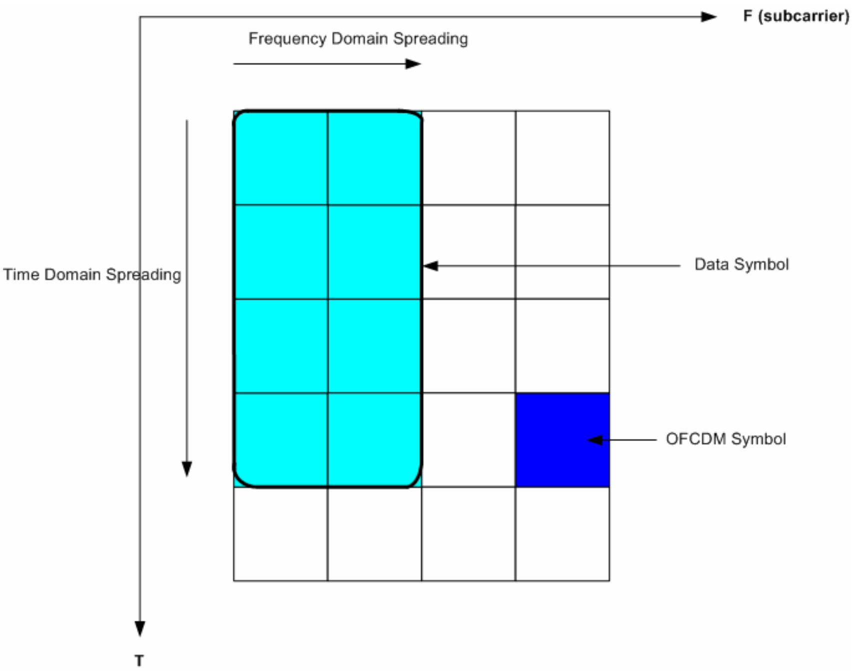

Figure 16. Spreading of one data symbol over 8 OFCDM symbols.
Source: (Acharya 2005)

Depending on the nature of the channel, the extent of spreading in the time and frequency domains will be adaptively adjusted. One of the fundamental characteristics of VSF-OFCDM is that of diversity. In a multi-user environment, VSF-OFCDM can used as a multiple access scheme for the wireless medium where the different users are code-multiplexed or spread by different CDMA code words or sequences. The spreading sequence is a combination of orthogonal short channelisation code and the cell-specific long scrambling code. Each chip of the resultant sequence is then allocated to the successive OFCDM symbols in the time domain and to the successive subcarriers in the frequency domain (Acharya 2005).

VSF-OFCDM as a wireless access scheme, when used together with adaptive coding and modulation and MIMO techniques etc, may provide data rates of up to 300Mbps[54] [55] in the forward link of a mobile communications system. Continued research into VSF-OFCDM is currently being undertaken by Japanese researchers to come up with an even more efficient and robust scheme.

3.8.4 Software Defined Radio (SDR)

A software defined radio is one whose behaviour is defined and controlled through software. It is said to be "a collection of hardware and software technologies that enable reconfigurable system architectures for wireless networks and user terminals" [16]. One of the reasons for the development of SDR is that it would provide a neater way to solve the requirements of new mobile terminals and base stations. By being software-based rather than hardware-based, SDR provides an efficient and comparatively inexpensive solution to the problem of building multimode, multiband, multifunctional wireless devices. SDR can be adapted easily to the situation; they can also be updated or enhanced whenever required.

Traditional radios are hardware-based equipment with components that are have specific functions e.g. a specific frequency range, modulation type (AM, FM) or output power[56]. SDR on the other will consist of a flexible radio that is controlled by software running on the device and which then makes the device adaptable to different transmit and receive requirements and the environment, just by having changes made to the software. According to the SDR Forum, they are "radios that provide software control of a variety of modulation techniques, wide-band or narrow-band operation, communications security functions such as hopping, and waveform requirements of current and evolving standards over a broad frequency range" [16]. SDR means that most if not all functions will be defined by software. These include waveform modulation and demodulation in both the transmitter and the receiver. Cost effective signal processing and converters (analogue to digital converters and digital to analogue converters) will be needed in SDRs.

[54] http://www.thestandard.com/article.php?story=20040604190846415 – cited 051205
[55] http://www.thestandard.com/article.php?story=20040604190846415 – cited 051205
[56] http://www.infoworld.com/article/04/11/19/Hnfccradio_1.html - cited 030805

Research and development work on SDRs have been going on for some time now. However, there are many difficulties faced in the implementation of SDRs in areas such as signal detection and speed of receivers. As mentioned by the SDR forum, "this is considered an enabling technology that will be applicable across a wide range of areas within the wireless industry" [16].

3.9 Discussion

This chapter has shown that there are different types of access technologies in the mobile and wireless industry today. Some of the technologies mentioned in this chapter are better versions of an earlier technology. These technologies are incremental in nature and mostly lead the technology on a path of sustainability. On the other hand, there are newer technologies in the industry that are radical in nature. These do not depend on older technology in their development and could in theory, lead the industry on a path of disruption.

Incremental technologies result in a linear progression of the technology. As mentioned by Olli Martikainen in his paper "Complementarities creating substitutes-possible paths from 3G towards 4G and Ad-hoc networks", the UMTS route is seen as GSM continuum or linear in development (Martikainen). This has been characterised by the overlay UMTS network that is built on top of the GSM/GPRS network. In many respects, UMTS was sold to operators as being the best path to evolution of the GSM network. Therefore, UMTS was one step further in the evolution path to GSM. Taking into account definitions that were introduced in the earlier chapter, it can be said that a technology like UMTS is considered an incremental technology and is one that builds upon some older technology and is introduced by changes that sustain the original technology.

Radical technologies on the other hand result in jumps in technology. This can perhaps be seen with one of the newer technologies as they progress in development and market acceptance. It is not easy to predict which radical technology will indeed become a technological disruption in the mobile industry. One can only say that many new technologies show the potential to become disruptions. 4G is seen by some as being sustaining to 3G. Others see 4G as being a disruption to 3G. It could probably be both. Many factors may be attributed to whether 4G will even see the light of day. Spectrum issues with regards to 4G are still unanswered and will be discussed in the WRF 2006. The definition of 4G poses some question as to which direction manufacturers and researchers are going. As discussed earlier, 4G is probably best described to be the culmination of several different advancements in technology and the introduction of radical new ones that will be compatible with older technologies of today.

Incremental technologies are probably sufficient to see us through in the next few years. But as the numerous technologies being developed progress and gain attention in the market, it may be case that these radical new technologies disrupt the market and begin to compete with the existing technologies. Technologies such as WiMAX have been viewed as being complementary to 3G. But as the technology increases in performance and coverage, it may become the technology of choice. Complementarity has been encouraged and the ITU has shown it supports complementarity of new technologies with older ones[57]. Unfortunately, it is impossible to predict whether new technologies will really complement or become substitutes to existing technologies.

Technology, especially mobile and wireless technology, has always been about performance and change. As one technology reaches the end of its product life-cycle, a newer improved version of it will develop or a radical new innovation will take its place. The constant battle with competitors to develop technologies with better performance and higher efficiency is one that characterises the mobile and wireless industry. Industry, however, must be careful not to develop so fast as to leave its users behind, as mentioned by Christensen (Christensen 1997).

The ability to bypass the mobile operator's network is an attractive one and some combination of short range and LAN/MAN type network could enable this. Also VoIP services will take off with new technologies that allow access to the Internet without having to pay high prices of mobile network access. WiMAX services have also been introduced in Denmark which could lead to users bypassing the traditional mobile operator's network and using VoIP services. Ad-hoc networks are another possibility of bypassing the traditional mobile operator's network. New technologies and services could potentially disrupt older and more conventional ones, leading to changes in the way we view and use the technologies at hand.

[57] Comments were obtained from plenary session speech by Lara Srivastava at the Hong Kong Mobility Roundtable, June 2005.

4 Evolution of Technologies to 3G and Beyond- Technical Considerations

Technology evolution is part and parcel of the mobile and wireless industry. In just 20 years, we have seen mobile technology go from analogue to digital and from first generation digital to 3rd generation digital. The technologies have evolved through both incremental as well as radical changes.

The conversion of transmission of speech from analogue to digital occurred when the industry went from first to second generation mobile networks. Second generation mobile telephony is characterised by the ability to have low priced, good quality person to person voice services. With 2G, there were mainly 4 standards: TDMA[58], PDC[59], CDMAOne and GSM. GSM was by far the most popular. Today, GSM has more than 1.4 billion[60] users worldwide.

GSM and the other second generation networks were designed for narrowband voice and data traffic (Landers et al 2002). These networks were vertically integrated such that they could combine different functionality e.g. transport, control and ser vices in the same network element. At the same time, this reduces the possibilities of different networks working together. This would have made it easier to reduce cost of ownership of the networks and to provide service portability options easily. Evolved 2G or GPRS was introduced on top of the GSM network in order to provide users with Internet connectivity. GPRS thus allows users to make use of the same (GSM) air-interface resources for data access and allows operators to charge users on data transferred rather than by time used (Landers et al 2002).

From GSM and other second generation networks, the mobile industry has progressed on to 3G. Third generation networks create a link between Internet Protocol (IP) and mobile communications. With 3G, users will be able to access data services at higher speeds and at the same time continue to have voice communication functionality. IP will play an important role in 3G.

This chapter will explore some of the more important technical considerations when looking at the development of mobile and wireless technologies. It will be followed by a description and analysis of the evolution of mobile and wireless technologies. The

[58] TDMA stands for Time Division Multiple Access and is a type of access scheme used in communication networks.
[59] PDC stands for Personal Digital Cellular and is the system used in Japan. This system was owned by NTT DoCoMo and is based on TDMA protocols.
[60] http://www.gsmworld.com/index.shtml - cited 040805

theory of disruptive technologies will be used to explain some of the evolution paths already taken and those that may be taken in the future.

4.1 Technical Considerations

For evolution of mobile technology to take place, first and foremost there are technical difficulties and issues that have to be addressed. Technology is what allows development of a service or a product and technical considerations that researchers and developers have to look at are numerous. When 3G was introduced some years back, these were many technical questions that arose. Some of the more important technical considerations have been listed here.

4.1.1 Speed

One of the most important considerations for 3G was speed. The fact that 3G was designed to be data centric meant that speed would be an important factor in user satisfaction. Second generation mobile telephony was based on circuit switched technology which was good enough for voice services, but with the introduction of data services, circuit switched networks were not efficient enough and the network resources was not utilised to its full capacity. By going to a packet switched network, such as on the fixed Internet, the network was able to operate more efficiently, although sufficient network capacity will still be a requirement. The advantage of packet switching over circuit switching is that with packing switching all available connections used for wireless Internet Applications are optimally utilised. This in turn, increases the connection speed and adds to user satisfaction.

4.1.2 Content

Content will mostly be provided to the mobile operator by content providers. The content is pre-produced such as text, audio or video. In the past, content providers were more of push- content providers where communication flowed in one direction from the content provider to the users. With evolved 2G and 3G however, interactivity is becoming more accepted and customisation and specific features are becoming more popular amongst users (Henten 2005). Content and data services are delivered on top of the basic network services. These are considered value added services.

With 2G, the most popular form of data service was that of SMS. This surprising success has opened the door to other data oriented services. With 3G, data services will grow in importance, in particular, multi media content. This is already seen today with different 3G operators offering video and music downloading services and other types of content services to users. Content and applications are vital components of a data service. And with the initial failure of WAP still fresh in operator's minds, it is essential that sufficient relevant and interesting content and applications be found on the mobile data service offering. As the number of 3G users increases, mobile operators will have to obtain huge amounts of content distributors and content providers and content aggregators in order to satisfy the customers. Gradually, the mobile operator is trying to bring the content aggregator and distribution service under their own wing and this not only consolidates their position in the new 3G market, it also gives them greater control over the type of content and services that the user will have.

Market segmentation will play a role in content provision, as always as different segments will have different requirements to they type of content they are able to access. For example, teenagers and young adults will be more interested in getting multimedia services like music and chat applications, while working adults may prefer to have access to company intranet services and news on the go. Services such as personalised content provision and location based ser vices are things that users will be looking for. Markets do not behave in a linear way and this is a consequence of user requirements being invariably subjective in scope and orientation. Very careful segmentation of the market is needed to cater to the different needs of each segment. Operators must always strive to provide the correct types of content and services to the right market segment.

4.1.3 Network Security

3G will result in the proliferation of content rich services using broadband access to the Internet. The broadcast nature of mobile communication and the increased use of mobile devices will no doubt introduce serious security vulnerabilities[61].

Security is an important technical consideration, both in the fixed Internet world as well as in the mobile world. Mobile users and network operators alike must be able to authenticate the identity of the communicating party and confidentiality and integrity mechanisms must be in place to protect the user's data as well as signalling information used in the network[62]. This all means that as we progress towards content and data rich applications, more personal data will be 'floating' around in cyberspace. Vulnerability in security will mean that data is compromised. This is of great concern when the data contains sensitive personal information such as bank account and credit card numbers as these may lead to misuse.

[61] http://choices.cs.uiuc.edu/MobilSec/ - cited 040805
[62] IBID

According to a 3GPP report on 3G security, there are several types of possible threats to the 3G system (3rd Generation Partnership Project 2001). Security threats have been segregated into those that associated with attacks on the radio interface; those associated with attacks on other parts of the system and those associated with attacks on the terminal (3rd Generation Partnership Project 2001).

The types of threats identified are listed here:

1) Unauthorised access to sensitive data (violation of confidentiality)
2) Unauthorised manipulation of sensitive data (violation of integrity)
3) Distributing or misusing network services (leading to denial of service or reduced availability)
4) Repudiation
5) Unauthorised access to services

Unauthorised access to personal data includes eavesdropping and masquerading (3rd Generation Partnership Project 2001). When an intruder eavesdrops, he is able to intercept messages without detection. This is in fact a violation of privacy. When masquerading, the intruder tricks an authorised user into believing that they are the legitimate system and the intruder is then able to obtain confidential information from the user. These two types of attacks are even more of a menace when users give sensitive information to certain service providers (3rd Generation Partnership Project 2001). When they do this, users expect that this information is kept confidential and safe. Sensitive data can be anything from medical or health information to bank or financial records. To keep this type of information safe from unauthorised access is one of the major concerns of providers as it poses a security threat in the air interface, which is open to all.

Unauthorised manipulation of sensitive data happens when someone who does not have the right to is able to manipulate or change sensitive data does so by modifying, inserting or deleting messages (3rd Generation Partnership Project 2001). This is a violation of integrity and is considered unethical.

When an intruder disturbs or misuses the network services, it means that he is intervening with the network by preventing an authorised user from accessing the services. The intruder is able to do this by jamming the user's traffic or by overloading the service (3rd Generation Partnership Project 2001).

Repudiation happens when the network or user denies actions that have taken place (3rd Generation Partnership Project 2001). This refusal to acknowledge an action is also considered a security threat to the network and the users on it.

Unauthorised access to services may occur when intruders get access into the network by masquerading as users or other network entities (3rd Generation Partnership Project 2001). Also, users of the network could misuse their access rights and get unauthorised entry to other services. This too is a security threat.

From this list of possible security threats, we see that these security breaches can occur at any one point in the chain of communication services. There is no one sure point of attack; attacks can and will occur anywhere from the radio interface, to user terminals including the USIM as well as other parts of the system. It can also be seen that many of these threats are similar to the ones experienced by fixed Internet users. It is therefore of great importance that security developers learn from the fixed Internet and to address issues with regards to security within a mobile network.

With single sign-on usage being looked at as part of the heterogeneous future of accessibility, security will remain one of the most important technical considerations for network operators, system developers and users alike. When a user signs in to one access, and is able to make use of others without going through a new authorisation and authentication process, security concerns here must also be considered as well.

4.1.4 Personal Privacy and Security

Personal privacy and security are somewhat related. A user expects to have personal privacy and security when using mobile services, be it voice or data services. To have privacy, security practices must be in place. But it is difficult to define privacy and security as they mean different things to different people and can be quite a complex issue when it comes to mobile communications because of the many new services and applications that appear with each new technology (Chiu and Praden 2004).

One of the more important points concerning privacy is that of personal data that is exchanged through the Internet and in particular, through the mobile Internet. As more and more personal data are being exchanged and used on the internet, either via fixed or wireless/ mobile access, it becomes more and more important that users are guaranteed a certain level of privacy when they engage in transactions required personal data or information. Network security will play a large part in providing users with data security and thus privacy. It is important that firms dealing with services and applications that handle personal data be able to store their client's data's securely and to make sure that transactions are safe. Banks and financial institutions in particular have more need for such security due to the nature of their services. Service providers and mobile operators should strive to develop good security practices for important transactions.

Camera phones have come under intense scrutiny in recent months. The fact that mobile phones can now take second role of a camera has caused some privacy issues to be raised. Taking photos of individuals without their consent is seen to be a breach of personal privacy and given the size and discreteness of camera phones, it is easily seen how camera phones could become a problem for personal privacy (Thornton 2004). Invasion of privacy with the use of camera phones is something that is being looked at by committees around the world. Some companies and government offices have banned the use of mobile phones by visitors so as to ensure company secrets are not leaked. Laws and government legislation drawn up to address the use of camera phones could in some ways help to protect personal privacy. This, however, is a rather complex issue as a camera phone could be used as a working tool (as in the case for plumbers or carpenters taking photos of their work for assessment by engineers or architects). On the other hand, the same camera phone could be a device committing invasion of privacy in another situation. There is a fine line between what should be private and what should not be private.

Another technology that has caused some controversy is that of location based services. Location based services make use of information about the location of the user and sends information regarding services in the area to the user (push services) (Sengupta). It is the ability to find the geographical location of the mobile device and to provide services based on this location information. There are several ways in which the users' location may be found (Magon and Shukla):

1) Manual methods
2) Global Positioning System (GPS)
3) Network Based Positioning

Manual methods require the user to specifically making his location own, by conveying this information to the other party. This means that the user has to actively participate in giving out his location information to the service provider.

GPS is a worldwide positioning system and is operated under the US Department of Defence. It makes use of 24 satellites orbiting the earth. It requires the user have a GPS enabled handset. GPS makes use of a technique known as Trilateration and it is a basic geometric calculation based on distances from other known locations (Magon and Shukla). Three satellites are used at each time in a trilateration calculation and makes use of the distance between the user and each of the satellites to determine the location of the user (Magon and Shukla). With the GPS system, users will be required to have GPS enabled handsets in order to use this facility. This would add to the cost of the service for the user.

Network based positioning relies on various means of triangulation from cell sites in which the mobile device is located. This allows the mobile device's location to be tabulated in relation to its cell site. There are various techniques to find the position of the mobile device such as:

1) Cell of Origin
2) Time of Arrival
3) Angle of Arrival
4) Enhanced Observed Time Difference (EOTD)
5) Assisted GPS.

Cell of Origin is the easiest technique to implement by network operators because the technology is built-in to handsets and the network. This method makes use of the cell location to give a general location of the mobile device. The accuracy is rather low at around 150 m in an urban area. However, it is cheap to deploy as it does not require any new hardware and any network is able to implement this (Magon and Shukla).

Time of arrival makes use of the difference in arrival times of a signal from the mobile device to more than one base station. This technique requires the use of location measurement units and this pushes up the cost of implementation. Although the accuracy is better than the Cell of Origin method, the costs involved and also dependency on visibility of transmission from the location measurement units (Magon and Shukla).

Angle of Arrival makes use of calculation of he angles at which a signal arrives at two different base stations from a mobile device. It makes use of triangulation to find the location of the device. However, in urban or built-up areas, this technique does not perform well due to the amounts of reflections and blockage of signals from buildings and other and other structures (Magon and Shukla).

EOTD is a method of positioning makes use of an overlay network of location measurement units. This is comparable to the Time of Arrival method but makes use of more measurement units to provide much better accuracy. However, because it is affected by structures such as buildings, it results in diminished accuracy (Magon and Shukla).

Assisted GPS makes use of both GPS and mobile technology and can be very accurate (up to 10 m). However, because of the use of GPS, it means that the mobile device will have to be GPS enabled and therefore not cost-effective for most users. This is best used by emergency services and navigation purposes. Like all other network based positioning systems, the accuracy of Assisted GPS reduces with clutter (Magon and Shukla).

With location based systems, customised information is sent to the user. This information could be traffic information of the particular area, weather conditions or other services. These are somewhat useful information that could assist the user at that point in time. However, it is also seen as a violation of privacy rights as this means that the user can be individually identified. In the United States, emergency services find this a useful tool in locating where help is required. But it brings in the 'big brother' effect in that users of mobile phones are being 'watched' at all times by service providers. There is much debate as to the extent of such services and how service providers can protect their customers from unsolicited information. According to Olesen et. al, the level of privacy can be categorised into 3 different levels (Olesen et al 2004). These are full privacy, partial privacy and non privacy. Depending on the type of service that users choose to have, different levels of privacy will be in use. The user will have to decide the amount of information to make known to the service provider and this should only what is necessary to receive the service (Olesen et al 2004). In most cases, users have to sign up for the customised information to be sent to their mobile phones. Debate over personal privacy and security will continue and until laws are drawn up to address these, users will have to be provided with as much information regarding the types of service they are requesting and the types of personal data and information that will be used. There will have to be a certain compromise between technology and privacy for that location based services to take off an achieve success.

4.1.5 Handoffs, Handovers and QoS

Handoffs refer to the process of transferring a voice call or a data session in progress from one cell transmitter and receiver and frequency pair to another cell transmitter and receiver using a different frequency pair without interruption of the call or session[63]. Handovers are the actual 'change of physical channel(s) involved in a call whilst maintaining the call' (Yacoub 2002). Diversity techniques are usually used in handovers to prevent call drops. Handoffs and handovers are needed to ensure that the mobile device is receiving the optimal signal when it is on the move. Handoffs are initiated for any of the following reasons (Yacoub 2002):

1) poor radio transmission conditions
2) radio channel capacity optimization
3) significant amount of interferences
4) signal level variability
5) operation and maintenance

[63] http://www.atis.org/tg2k/_handoff.html – cited 161105

There are different types of handovers within mobile networks. The most common and basic type occurs within the same network operator's domain. For example, when a mobile user moves from one GSM cell to another GSM cell, the call will be transferred from one cell to the next without breaking or interrupting the call. The second type of handover happens between different mobile operator networks, where the two networks make use of the same technology and air interface- for example when a user moves from the German border to France, the call has to be seamlessly transferred from one network operator to the next. In most cases, soft handovers established where the mobile terminal is connected to the original cell base station and the new cell base station concurrently and the handoff occurs when the signal strength to the new base station reaches a high enough threshold. This is known as roaming. Handover from one network to another is needed when crossing international borders. The third type of handover occurs between two different systems where different technologies and air interfaces are used. This could occur when a handover has to be established when a user moves from an area with W-CDMA coverage to one with only GSM coverage. This is known as an inter-system handover.

A handover is initiated by either the mobile node or by the network. In a mobile-initiated handover, the mobile node makes the initial decision to initiate a handover. In a network-initiated handover, the network makes the initial decision to initiate a handover (Manner 2004).

A handover is also either mobile-controlled or network-controlled. A mobile-controlled handover means that the mobile node has the primary control over the handover process. A network-controlled handover is one which is primarily controlled by the network (Manner 2004).

A handover decision involves measurements about when and where to handover to (IETF 2004). Therefore, a handover can be network- assisted or it can be mobile-assisted. In a mobile-assisted handover, the mobile node provides information and measurements to the base station which will determine the execution of the handover. In a network-assisted handover, the base station collects information and measurements that can be used by the mobile node in a handover decision (Manner 2004). It may be possible that both the mobile node and the access router provide information and measurements and decide on the handover. It is also possible that an unassisted handover takes place, where neither the mobile node nor the base station provides information to each other (Manner 2004).

Quality of Service (QoS) is the level of network quality that a user experiences while making use of the network[64]. This is something that has been long established in the

[64] http://www.mnlab.cs.depaul.edu/seminar/fall2003/WLANQoS.pdf - cited 230805

fixed communications industry and has been adopted by mobile communications. Quality of service is a measure of a network's performance and it reflects the network's transmission quality and service availability. It is often characterised or measured according to the number of bits per second transmitted and received (bandwidth), by the delay through a network, the amount of jitter or the network reliability. Because of intrinsic differences, different networks have different classes of service and hence different qualities of service (Guo and Hemant 2002). There are certain criteria that just do not match because of the different technical specifications. Achieving similar quality of service offering throughout the different types of mobile and wireless networks and through the fixed networks is a difficult undertaking. For example, when a user roams from a WLAN network into a 3G UMTS network, he would expect the same quality of service in his data service. However, what he will probably experience is a drop in data rates as he moves from a WLAN to a 3G UMTS network. This is a potential scenario of the future where heterogeneous networks are in place and devices that are able to handle different types of accesses are available.

Roaming was most widely established with GSM standard where users are able to roam internationally by making use of their mobile provider's partner networks [17]. This means that with the same GSM phone, users are able to place a call in their home network, but also in the network of another country which their operator has a working agreement with. With UMTS networks, a similar arrangement is expected to be in place for users roaming internationally. The difficulty will probably come with roaming between different networks such as in the case mentioned earlier. Inter-network roaming will represent technical challenges to the different network operators. One of the problems is that of QoS. But before we can even consider QoS, the networks will have to be somehow connected. Inter-connectivity will be discussed in Section 4.2. Only when interconnectivity is available between different networks can users roam between them. After connectivity has been established, different quality of service levels can be instituted to different customer. Classes of service are important for operators in market segmentation exercises. Higher quality classes maybe made available to corporate users or customers who demand higher bandwidth or speed, while lower quality classes maybe made available to consumers or users who do not need such high bandwidths. This sort of segmentation is somewhat similar to that in the fixed communications world. This is not as easy as it seems because different networks will have different ways of differentiating levels of service. What one network operator considers being a high level of QoS may only be considered a medium level QoS by another network operator. These and other differing differentiations will have to be sorted out and mapped before a particular service is able to perform with similar service over different networks.

Handoffs are usually classified as either vertical handoffs or horizontal handoffs. A horizontal handoff is a handoff between two network access points that use the same network technology and interface[65]. This could happen when a mobile device moves from one WiFi network domain into another WiFi domain. The connection is disrupted because of the user's mobility and the handoff is therefore considered a horizontal handoff. A vertical handoff is a process of switching the ongoing connection from one interface to another (Stemm and Katz1998) (Chenm et al 2005). A vertical handover could occur when a mobile devices moves from a WiFi network into a GPRS network or a UMTS network. This is considered a vertical handoff because the device goes through different technologies and air interfaces as it moves from one network to the next. Smooth vertical handoffs are more difficult to achieve compared to horizontal handoffs. To maintain the same QoS when a vertical handoff is established is even harder to achieve as well.

As with GSM, handoffs and handovers within 3G UMTS networks are an important issue. Successful handoffs and handovers are key factors to the heterogeneity of the network and there are issues that have to be solved before these can occur smoothly. With beyond 3G networks, handoffs and handovers between different types of networks will also have to be done smoothly to ensure service continuity for users. All this poses technical implementation questions as to how smooth handoffs and handovers and thus quality of service may be achieved. There are generally three approaches that have been developed to interconnect, for example, a UMTS network and a WLAN network. The three approaches can be differentiated by the amount of coupling between the networks. These will be looked at in section 4.2.2.

4.1.6 Devices

Devices of the future will have to cater to more demanding applications, services and different types of accesses. Multi-mode and multi-band terminals will be the norm (Cummings 2004). Multi-band terminals allow users to access WCDMA or CDMA2000 or other 3G networks, while multi-mode means that the terminals can work in both 2G and 3G networks. Like dual-band and dual-mode terminals[66] of today, these new terminals will allow users to seamlessly cross from one network to another without the user's knowledge that a change of network has taken place. There will also be a need for mobiles to use other wireless networks such as WiFi and perhaps, WiMAX and Mobile-Fi. This makes it a requirement to have multi-mode devices that can work throughout different types off networks. In South Korea[67], dual-band and dual mode phones that operate in WCDMA and CDMA2000 mode were introduced, allowing users to roam between both types of networks. However, problems[68] still exist in such

[65] http://www.cs.ucla.edu/ST/index.html - cited 161105
[66] http://www.bsnl.in/Telecomguide.asp?intNewsId=33851&strNewsMore=more – cited 220805
[67] http://www.telecomasia.net/telecomasia/article/articleDetail.jsp?id=133221 – cited 220805
[68] http://www.3gnewsroom.com/3g_news/jun_04/news_4652.shtml – cited 220805

handsets and will have to be solved slowly. Other types of dual mode devices roam allow use between GSM and WCDMA networks. Slowly, many more such devices will be introduced by device manufacturers and later, multi-mode multi-band devices will also come into the scene. With the number of accesses and frequencies that new mobile devices have to deal with, software defined radio interfaces may be a consideration for such devices.

Devices of heterogeneous networks will include many different functions. We already see this pattern of increased functionality in the mobile devices of today. All this places great demands on terminal or handset manufacturers to develop devices that are able to cope with the increase in access types and functions. Terminals of the future will certainly have to be multi-mode and multi-band. They will probably also have to contain processors with increased processing speed and richer and bigger colour displays. An important obstacle to overcome is that of battery life. Research into fuel cells is one example that could revolutionise mobile devices. A fuel cell is a device that converts hydrogen and oxygen into electricity and heat[69]. This would enable the battery to recharge constantly and this would overcome lack of battery life characterised by today's mobile device batteries. Today's batteries are plagued with short usage time. As applications and functions get more complicated, more battery power is needed.

Technical considerations abound, when it comes to the next generation of mobile and wireless technologies. Those technical considerations that have been looked at here are but a handful of all of the issues that need to be addressed. There are many aspects that have to be looked at and solved, especially if the goal is to have a true heterogeneous, seamless network, where users have security, quality of service, roaming between different types of network; all these with the use of a single terminal or device. Development work into many of these aspects continues even as new services, applications and other technology development take place. Technology is an important part of the mobile and wireless industry, when one looks at the evolution of mobile/wireless networks; it is technology that is a key driving force and a significant contributor to changes, both sustaining and disruptive, in the mobile and wireless industry.

4.2 Interconnection of Networks

In order to have a heterogeneous network and seamless handovers between different mobile and wireless systems, as will be the requirement for future mobile and wireless network, inter-connectivity between different networks must, first and foremost, be

[69] http://www.pcworld.com/news/article/0,aid,106710,00.asp – cited 220805

established. Interconnection between different networks and systems will ensure that users are able to have smooth handovers as they move between different systems. This is all part of the beyond 3G vision. It is the ability to have connectivity at any time and at any place, irregardless of the type of network and access.

Interconnectivity can be categorised into two types, intra-network (or intra-system) interconnectivity and inter-network (or inter-system) connectivity. The main difference lies in the fact that intra-network interconnectivity results in networks with similar technologies and air interfaces being able to inter-work and that inter-network interconnectivity results in networks with different technologies and air interfaces being able to work seamless with one another.

Intra-network connectivity has already been proven a possibility with GSM- where different networks all over the world, working on the GSM standard were able to inter-connect and allow users to make use of networks other than their home networks whenever they were in a foreign country. The main reason for this was that different countries were willing to adopt the same standard and this has, in a way, contributed to the growth of GSM in the world.

4.2.1 Interconnectivity between WCDMA (UMTS) and GSM

Interconnectivity between UMTS and GSM is considered a basic requirement in the deployment scenario of UMTS. This is because it is unlikely that UMTS can be deployed in all regions of a country at once and will therefore need to fall back on GSM where it is not deployed initially. This, in turn, calls for interconnectivity to be established between the GSM network and the UMTS network. This is not easy as it seams. To study this, the different radio access networks should be analysed.

Figure 17 shows the GSM/GPRS network very minimally. The Base Station System (BSS) consists of The Base Station Controller (BSC) and several Base Transceiver Stations (BTS). The BTS and BSC are connected by the Abis interface and the BSC is connected to the GPRS core network with an A interface and a Gb interface (Kate-kom.com 2005). Alternatively, the time slots on the existing A link may be allocated for GPRS (Kate-kom.com 2005). The A interface is primarily used for connectivity to the GSM backbone while the Gb interface connects the GPRS upgraded BSS elements to the GPRS core network. The main difference between the GSM network and the GSM/GPRS network is that the latter allows packet-switched mobile data services. New packet based functionality is introduced to the original GSM system to cater for transmission of packet data.

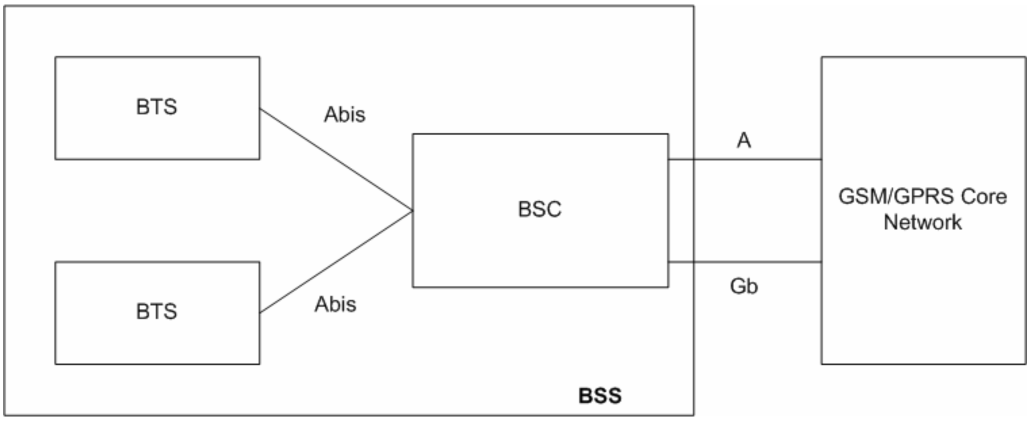

Figure 17. GSM/GPRS network
Source: (Kate-kom.com 2005)

The second step in the evolution path from 2G to 3G is that of EDGE. EDGE introduces a new modulation scheme. The 8-PSK (Phase Shift Keying) modulation technique is used because it is able to support higher transmission rates to increase the network capacity (Kate-kom.com 2005). EDGE will still share GPRS network elements and some changes will have been some changes made to the hardware as well as adaptation of the signalling structure within the BSS (Kate-kom.com 2005). EDGE traffic will be routed making use of the Gb interface which is allocated on the Abis interface from the BTS to the BSC. Figure 18 shows how the basic GSM/GPRS/EDGE evolved from the earlier GSM and GSM/GPRS network will look like. The BSC is then connected to the existing GSM/GPRS core network by the A and Gb interfaces, as was done previously in the GSM/GPRS network.

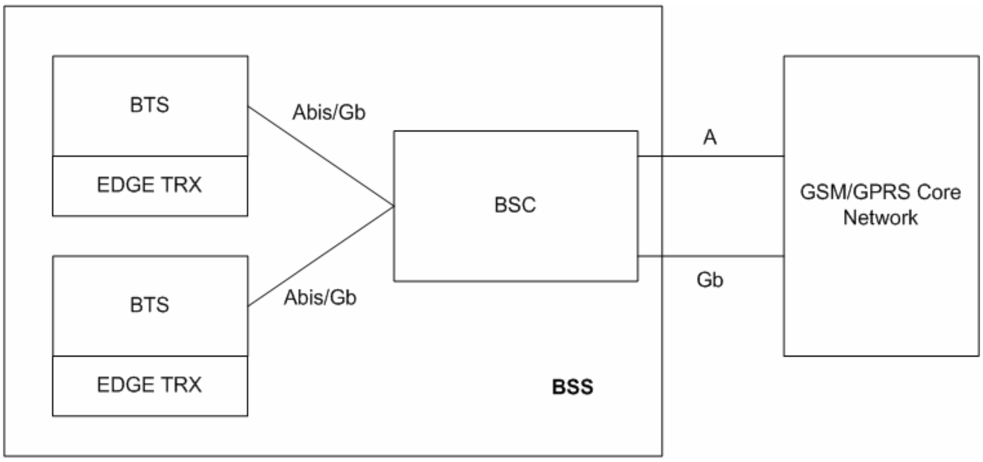

Figure 18. GSM/GPRS/EDGE network
Source: (Kate-kom.com 2005)

The next step in the evolution is to introduce the UMTS radio access network. The UMTS Terrestrial Radio Access Network (UTRAN) is the entire radio access for the UMTS 3G network. UMTS, as already mentioned earlier, is based on WCDMA radio access technique and this, together with the UTRAN, will provide higher bandwidths and better spectrum efficiency which allows for higher data rates and hence high bandwidth multimedia services.

Figure 19 shows the UMTS Radio Access which consists of a GERAN and a UTRAN. The GERAN (GSM EDGE Radio Access Network) is part of the original GSM/GPRS/EDGE network. The GERAN architecture within the UMTS radio access should, in reality, be backward compatible with the original GSM/GPRS unit, making use of the A and GB interfaces to the core network (Kate-kom.com 2005). In addition to the GERAN, there is the UTRAN. The UTRAN consists of Node Bs (which are equivalent to the BTS in the GERAN) and the Radio Network Controller (RNC) (which is equivalent to the BSC in the GERAN) (Kate-kom.com 2005). The RNC is connected to the UMTS core network via a Iu interface. This interface will also exist to connect the BSC to the UMTS core network. With the UMTS radio access, both GSM/GPRS/EDGE and UMTS users can be connected to the same core network.

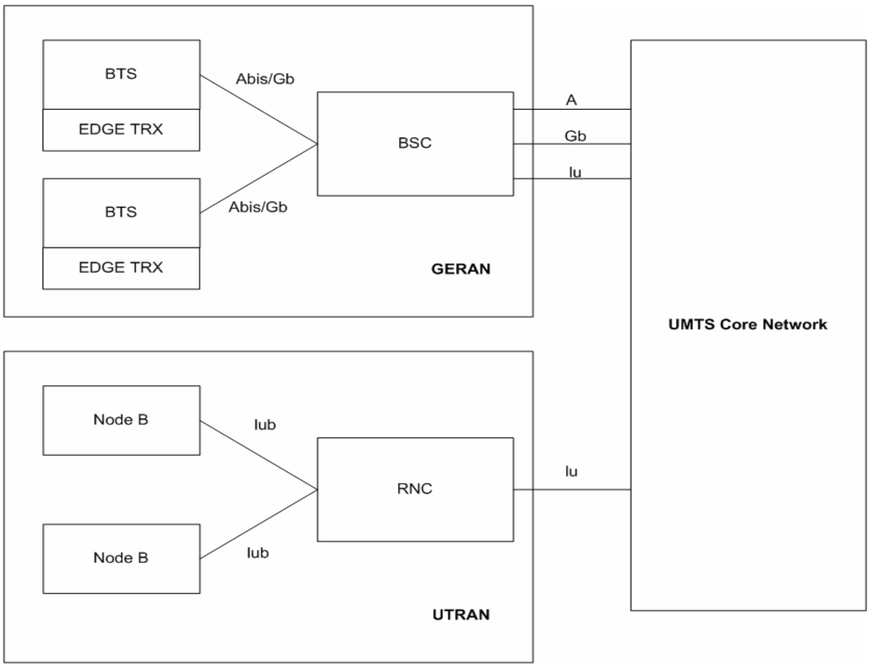

Figure 19. UMTS radio access
Source: (Kate-kom.com 2005)

GSM and WCDMA or UMTS is already deployed concurrently in many countries, with UMTS being deployed predominantly in the urban areas while the rest of the country still relies on GSM/GPRS/EDGE. There are basically two ways of having interconnection. At the beginning the first method would be most probable and likely that UMTS radio technology is deployed primarily in UMTS specific equipment. This is to ensure that there is no affect on existing GSM equipment (Drevon et al 2003). Later on, the second method would see a module consisting of both GSM and UMTS radio technology be introduced to lower costs and improve resource management. This module could consist of a multi-standard RNC/BSC (Radio Network Controller/Base Station Controller), which sees to both GSM and UMTS standards. This module will see to the smooth progress to a fully UMTS network. It is envisioned that both GSM and UMTS must work together and therefore handoffs between the two networks is essential for users while they are mobile (Drevon et al 2003). It was reported that "at least 40 WCDMA (UMTS) operators are also deploying GSM/EDGE in their networks for service continuity and the best user experience of voice and enhanced data services throughout their networks"[70]. Interconnectivity between WCDMA and GSM is essential as when first deployed, it is likely that WCDMA will not be able to give full coverage over the entire country until a later date. This leaves rural areas covered only with GSM/GPRS/EDGE Also, users who have not subscribed to WCDMA or UMTS should not be left stranded. The operator will have to cater to their GSM users while slowly switching them over to the new network to give continuity.

When interconnecting a UMTS network to that of an existing GSM network, there are several things that would affect the efficiency (Kate-kom.com 2005):

1) backhaul transmission using leased lines
2) bearer technology (TDM)
3) mapping of QoS across networks

Today, most mobile operators still lease 2M (E1)or 1.5M (T1) or 155M (STM-1) leased lines from fixed line operators. Leased lines are still used to connect the mobile network with the fixed network. Within the GSM network, BTS are still connected to the BSC using E1 leased lines. As traffic increases, this E1 line may not be sufficient to provide services to all users and would have to be upgraded.

In the backhaul, traditional circuit switched TDM is used as the multiplexing technology. This is inefficient because it is a static multiplexing technology that each channel on the interface is multiplexed irregardless of whether it is carry any traffic or not, channel resource is not efficiently used here.

Mapping of QoS levels across the different networks is also something that has to be done to ensure that the quality of the different services remain on the same level (or almost on the same level) as before when roaming takes place. This is quite a huge task as even in the fixed network world, different operators have different ways of distinguishing QoS. This sometimes leads to difficulty when interconnecting between fixed networks. Between mobile networks, this problem will also exist as there is no one fixed way of distinguishing between levels of service. Operators will therefore have to work together to establish correct mapping of QoS between their networks.

Generally speaking, however, 3G network operators have chosen to deploy loose coupling inter-working strategies between 3G (UMTS networks) and 2G (GSM networks) (Huawei Technologies 2005). Depending on the upgrade taken with the GSM network, different inter-working strategies can be supported (Huawei Technologies 2005).

[70] http://www.gsacom.com/gsm_3g/index.php4 - cited 211105

4.2.2 Interconnectivity between WCDMA (UMTS) and WiFi

Interconnectivity between a WCDMA network and a WiFi network requires that two very different networks work together. One is a mobile network, which is considered a higher tiered network while the other is a LAN network, which is considered a lower tiered because of its lower mobility. Differences in QoS and transmission speeds are something to contend with. Interconnectivity between WCDMA and WiFi, as mentioned by Tsao and Lin can possibly be achieved with several different methods (Tsao and Lin 2002):

1) Mobile IP (loosely coupled)
2) Gateway Approach
3) Emulator Approach (tightly coupled)

The main difference in the three methods is the amount of coupling between the networks to achieve interconnectivity. Mobile IP is considered a loosely coupled method to achieve interconnectivity between a UMTS network and a WiFi network, while the emulator approach is considered a tightly coupled method. The gateway approach is somewhere in-between.

The first approach to interconnect UMTS and WLAN is by means of Mobile IP. Mobile IP introduces mechanisms in both the UMTS and the WLAN networks to provide IP mobility for roaming purposes. Mobile IP works by ensuring that the mobile user is able to access the Internet with the same IP address, even if the user roams from one physical layer to another, e.g. from a WLAN network to a UMTS network. Mobile IP requires that home agents and foreign agents be installed in the networks involved and also requires that the user terminal has Mobile IP features. Figure 20 illustrates the mechanism of sending a packet using Mobile IP.

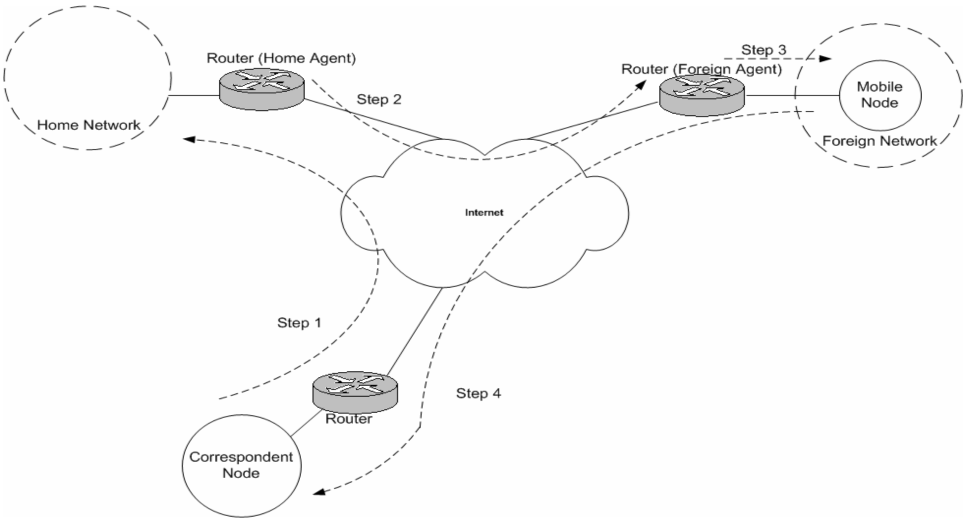

Figure 20. Packet delivery using Mobile IP
Source: (Schiller 2003)

In the first instance, a packet is sent to the mobile node from a correspondent node. This could be a stationary node or another mobile node. As the correspondent router does not know the location of the mobile node, it will send the packet to its home network, via the home agent (Step 1) (Schiller 2003). The home agent then adds a new header with the new COA (Care-off address) as the new destination address and the home agent address as the source. It then encapsulates the packet and tunnels it towards the foreign network, through the foreign agent (Step 2) (Schiller 2003). At the foreign agent, the packet is decapsulated and the original packet is forwarded to the mobile node with the correspondent node address as source and Mobile node as the destination (Step 3) (Schiller 2003). When the mobile mode sends a packet back to the correspondent node, it uses the correspondent node's address as the destination and its own fixed IP as the source (Step 4) (Schiller 2003).

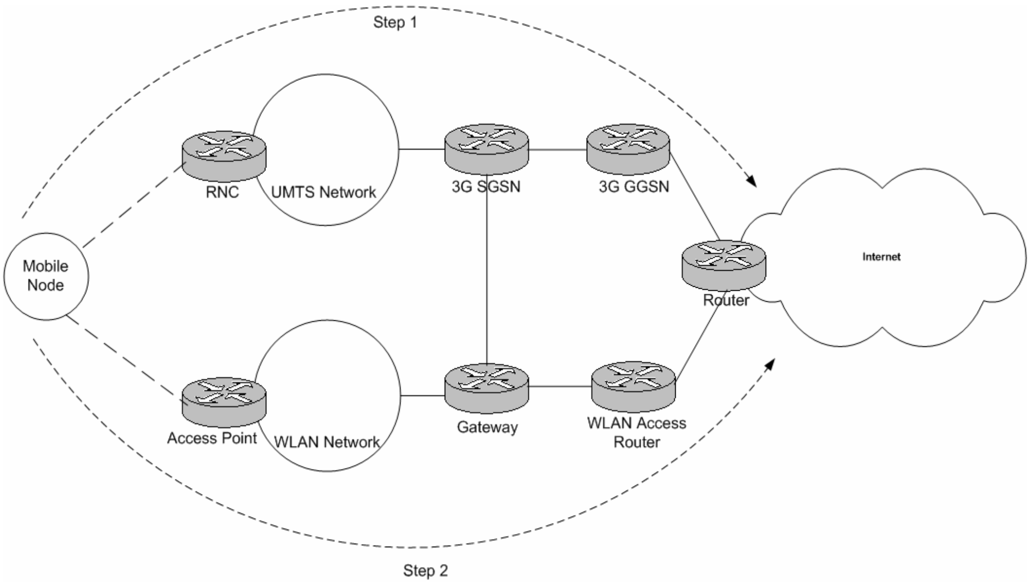

Figure 21. Simplified Gateway approach architecture
Source: Adapted from (Tsao and Lin 2002)

The second approach is the Gateway approach. The Gateway approach introduces a new logical node that acts as a connecting link between the two different networks (Tsao and Lin 2002). It resides in between the two networks but acts as an internal device of each of the two networks (Tsao and Lin 2002). This is shown in Figure 21. The node is used to exchange information required about a user and forwards packets when a user roams from one network into the other (Tsao and Lin 2002). This approach works as if the system is made up of two separate networks and is able to function independently, e.g. a peer to peer network (Tsao and Lin 2002) (Varma et al 2003). The gateway node is used only to forward packets to a user that has crossed the boundary of one network to the next. The mobile node starts connected to the UMTS network (Step 1). When a WLAN network comes into range, it will initiate handover procedures and to attempt to obtain a gateway address in order to perform inter-system handover procedures (Tsao and Lin 2002). The gateway will respond with its IP address. Once the mobile node obtains a gateway address, it sends a routing area update to the gateway, using its original IP address from the UMTS network. The gateway will then send a standard Update Packet Data Protocol (PDP) Contexts Request to a Gateway GPRS Support Node (GGSN) (Tsao and Lin 2002). From this point, the GGSN determines that the mobile node has moved from the UMTS network to the WLAN network (Tsao and Lin 2002). The gateway becomes the

Serving GPRS Support Node (SGSN) temporarily. Packets to the mobile node now should go through the gateway instead of the SGSN (Step 2) (Tsao and Lin 2002). The GGSN sends a standby command to the SGSN not to delete the mobile node's session as it may roam back into the UMTS network and this standby mode would be better for performance (Tsao and Lin 2002). Incoming packets to the mobile node will be recognised by the GGSN and tunnelled through to the gateway (Tsao and Lin 2002).

There are several advantages to the Gateway approach (Tsao and Lin 2002):

1) Handover is faster and packet loss is less than mobile IP approach.
2) Mobile IP is not required.
3) The two networks are sufficiently loosely coupled to work autonomously and to handle their single mode users independently.

Today, however, it is still not possible to deploy this approach due to several reasons (Tsao and Lin 2002):

1) UMTS and Internet standards are insufficient to support this approach
2) Some UMTS protocols have to be refined
3) Exchange of Authentication, Authorisation and Accounting (AAA) and Home Location Register (HLR) information have to be further defined

The third approach is the Emulator approach. The Emulator approach makes use of the WLAN as an access stratum into a UMTS network (Tsao and Lin 2002). The Emulator approach is shown in Figure 22.

Making use of layers 1 and 2 of the WLAN stratum, the UMTS access stratum is replaced. The WLAN base station can then be viewed as a UMTS RNC or a Serving GPRS support node (SGSN). This means that the gateway is the single point of entry to the Internet. The session management and mobility management are still handed by the UMTS network. The emulator approach tightly couples the two networks and the WLAN network is viewed as a slave of the UMTS network (Varma et al 2003). Mobility in a tightly coupled scenario follows that of UMTS mobility management (Varma et al 2003). When the mobile node is in a UMTS network, it would follow GPRS mobility management protocols (Step 1). When it detects a higher bandwidth access such as WLAN, it would make use of the WLAN access instead. The mobile node first associates itself with a WLAN access point (Varma et al 2003). It then goes through an inter-SGSN Routing Area. The RNC emulator then acts as the new SGSN and the original 3G SGSN becomes the old SGSN (Varma et al 2003). The Mobile node will then be connected in the WLAN network, which is connected to the UMTS network via the RNC Emulator (Step 2) (Varma et al 2003). New packets arriving at the GGSN will be tunnelled to the RNC Emulator or new SGSN to the Mobile node (Varma et al 2003).

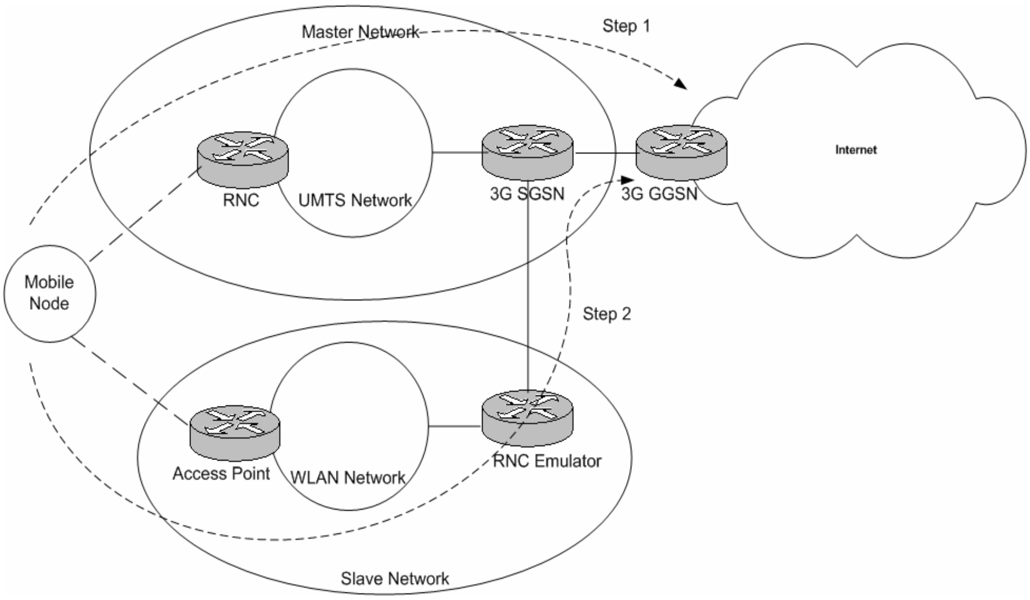

Figure 22. Simplified Emulator approach architecture
Source: Adapted from (Varma et al 2003)

The three methods to achieve interconnectivity between networks mentioned so far make use of network elements to establish and follow through with the mobile user roaming between networks. These are system or network initiated handovers. The differences in coupling lead to how much each network can function on its own and the level of inter-working with other operators using roaming agreements.

There is another possibility and that is to have interconnectivity controlled and established by the user terminal. As the user roams from one network to another, the terminal will initiate handover procedures and enable the user to switch from one type of network access to another seamlessly. Software defined radios is one technology that will allow each radio interface to be downloaded onto the user's terminal as and when it is needed and the terminal will self-configure itself to accept the new access technology as it roams into it. In this way, the networks do not have to be physically interconnected or linked. Roaming will be achieved by means of a powerful mobile terminal. Although this is a possibility and research work is being done on this topic, there are many problems to overcome. Some of these problems include:

1) battery life
2) processing power
3) algorithms to calculate and execute handover procedures
4) antenna technology
5) Frequency selection
6) Hardware configuration

Interconnectivity is amongst one of the most important considerations as operators and manufacturers move into 3G and beyond 3G. The different approaches are available today. However, shortcomings in each of them exist and may not work in a deployment scenario. Protocols existing today are insufficient to cater to the requirements of such handovers and delays and packet loss still exist. In a fully heterogeneous and ubiquitous network, it is necessary that roaming, interconnectivity and interoperation are seamless.

4.2.3 UMA (Unlicensed Mobile Access)

UMA is a recent development. The aim of the UMA effort is to work on and develop a set of technical specifications for the extension of voice and data GSM/GPRS services [18]. This set of specifications will be published for services over the unlicensed spectrum with technologies such as Bluetooth and WiFi [18]. With members ranging from equipment manufacturers, device manufacturers and operators, it is hoped that the set of specifications will be adopted in the future in order to for it to be approved by a formal global standards organisation [18]. The specifications were published in September 2004 and will be taken up by the 3GPP for future standardisation[71].

[71] http://www.wifinetnews.com/archives/004825.html - cited 170106

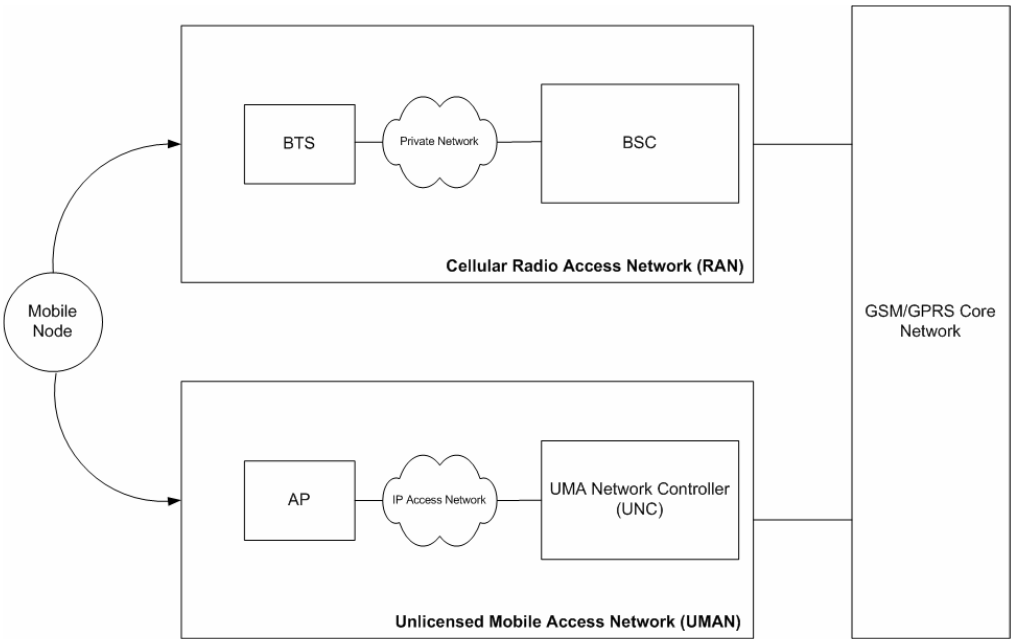

Figure 23. UMA technology
Adapted from [18]

The idea behind UMA is to make use of unlicensed mobile access technologies in order to access GSM and GPRS services. Instead of using a GSM or GPRS air interface, UMA allows access to the GSM and GPRS network via the use of an unlicensed technology such as Bluetooth and WiFi. This is to enable seamless roaming delivery of mobile services; and in order to do this, a new network element called the UNC or UMA Network Controller is introduced. Figure 23 illustrates how UMA technology works.

A mobile subscriber, denoted by the mobile node, is equipped with a dual-mode handset which makes access to both WiFi and GSM/GPRS possible. Access to the GSM/GPRS core network via the cellular radio access network takes place as in any normal mobile call [18]. But when the mobile node is UMA- enabled, it will mean that hen the mobile node roams into an area with either WiFi or Bluetooth connectivity, it is able to make contact with the UMA Network Controller (UNC) [18]. This will allow the mobile node to access the SM/GPRS core network via an Unlicensed Mobile Access Network (UMAN) [18]. On detecting and connecting with a WiFi network, the mobile node will contact the UNC over the IP Access Network to be authenticated and authorized to gain access to the GSM/GPRS Core Network [18]. Once the connection is approved by the UNC, the mobile node's location information is updated in the Core network and from then, all mobile and voice traffic is routed through the UMAN rather than the RAN [18]. With UMA, the mobile user is able to roam between the mobile and wireless network without losing a voice or data session during handover.

UMA will be comparatively easy and inexpensive to deploy as there are no major changes to the core network[72]. The most expensive component of the UMA solution is expected to be the user device. The UMA-enabled user device will have to be equipped with a UMA client software used to communicate with the UNC[73]. Mobile operators are working closely with device manufacturers in developing devices specifically for UMA access. They will however, most likely block VoIP services that would compete against their mobile services[74]. This will be a matter of some contention and it remains to be seen how UMA will develop and how operators will choose to price and market this product, as well as how users will take to UMA.

4.3 Evolution of Technology

Evolution of mobile and wireless technology is a continual process that started with the beginning of mobile telephony. Some of the technical considerations in mobile technology have been explored in this chapter. The evolution of mobile and possible migration paths will now be discussed. On the road to 3G and beyond 3G, all mobile operators have had to consider the best path for upgrading to the new technology platform. There are several factors that had to be considered on this road to upgrade.

One of the factors that had to be considered by mobile network operators was their original 2G or 2.5G network infrastructure. The most common 2G network that exists is still that of GSM and for 2.5G, it was GSM enhanced with GPRS to enable higher speed data transfers to and from mobile terminals. GPRS is an overlay over the existing network which provides packet data services, making use of the same air interface. This is done with the addition of two new network elements, the SGSN and the GGSN and a software upgrade. Most TDMA systems have been upgraded or incorporate GSM systems and will follow the same upgrade route as other GSM operators. IS-95 systems using CDMA (CDMA-One) air interface would have used another upgrade path. Figure 24 shows how these two networks maybe upgraded to 3G networks.

[72] IBID
[73] IBID
[74] IBID

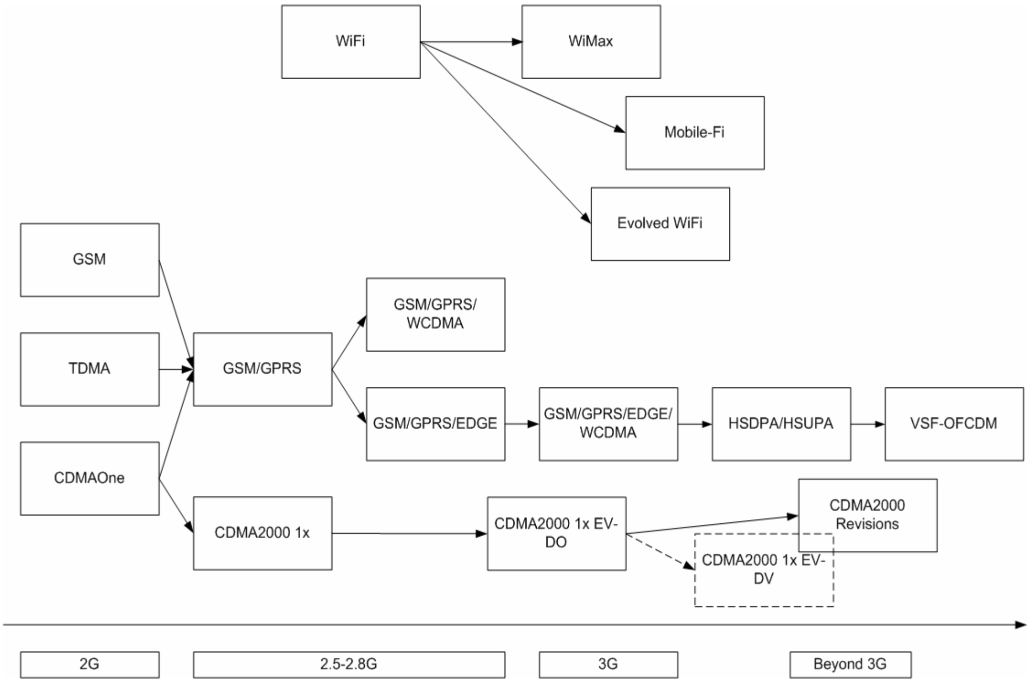

Figure 24. Migration paths for different mobile platforms
Adapted and developed from: (UMTS Forum White Paper Aug. 2003)

As seen in Figure 24, GSM operators and TDMA operators will most probably first choose to upgrade to GPRS in their existing network. When GPRS was first deployed with GSM, it was an opportunity for GSM and TDMA operators to gain experience with data services. From the GSM and TDMA network operator's point of view, GPRS gave them an indication of how advanced data services could be taken up by its customers. Since then, making use of GPRS to access data services has grown to be an essential part of many users' lives.

After GPRS had been introduced, there are generally two ways in which to upgrade to a fully 3G network. The first way is to deploy a WCDMA network directly. This 3G network will, however, have to inter-work with the existing GSM/GPRS network with issues such as seamless security and smooth call handovers taking place between the networks. The alternative to this, which has been adopted by several operators, is to introduce and intermediate EDGE which gives enhanced data services. EDGE has been considered by some to be a cheaper alternative for GSM/GPRS network operators (compared to UMTS) and this gives customers enhanced data rates. WCDMA can then be deployed at a later date when costs of deployment are lower. The end product of this path would be a network that is a combination of GSM/GPRS/EDGE/WCDMA. A combination network is required in the beginning because not all users would migrate immediately to the newer platform and also, deployment of the new network would probably take place in stages, making use of the older platforms to fill in the gaps in the new network. Again, the networks would have to be interconnected so that users experience seamless roaming when they have to move from one network to another.

IS-95 operators, i.e. operators that deploy CDMAOne networks, have, in general, followed a different path to upgrade their networks to a 3G network. Most operators in the Americas have deployed CDMAOne networks and to enhance this, the first step towards a fully operational 3G network is to introduce CDMA2000-1x technology. CDMA2000 1x is evolved from CDMAOne, hence the cost of upgrade is kept to a minimum. Subsequent to this, the 1x network would have to be enhanced to make it possible to introduce new data services. With CDMA2000 1x EV-DO, mobile network operators are able to provide users with data services in addition to their voice services. CDMA2000 1x EV-DV was originally planned to offer even higher data speeds to be available along with voice calls being on the same channel. Interest in EV-DV, however, has not been as great as Qualcomm had anticipated and work on the EV-DV standard has all but stopped. Instead, Qualcomm, the 3GPP2 and others have decided to concentrate their efforts on EV-DO and revisions to this standard in order to address some of its shortcomings (Albright 2005). One such shortcoming is that the EV-DO standard is optimised for Data Only, as its name indicates.

It is interesting to note that some CDMAOne operators in the Americas actually chose to deploy a GSM/GPRS network. One reason for such a choice is probably that of revenue from roaming agreements with other GSM/GRPS network operator worldwide. This indicates that it is no more difficult to migrate to 3G from GSM than it is to do so from CDMAOne (Saugstrup and Henten 2004). The revenue gained from GSM roaming agreements and the ability to harmonise with GSM networks the world round can be used to explain the motivation in choosing to deploy GSM/GPRS instead of CDMA2000 1x. It is also interesting to note that in South Korea, one of the most advanced countries in terms of mobile and wireless technologies, operators have traditionally worked with the CDMA family of technologies but have also adopted WCDMA as part of their strategy moving forward and are working with two networks, requiring the use of dual-band dual-mode mobile terminals[75]. Operators in South Korea introduced CDMA2000 1x EV-DO in early 2002 and WCDMA networks in late 2003. However, the uptake of WCDMA services has been considered a failure so far

[75] http://www.3gnewsroom.com/3g_news/oct_03/news_3837.shtml - cited 051205

and operators have cited the lack of available handsets and limited network coverage to be the cause[76].

WiFi has turned out to be more successful in certain markets than originally thought of. As the cost of equipment decreased, and deployment costs mirrored this downward trend in cost, both mobile operators and other independent WiFi operators have deployed WiFi hotspots quite aggressively. Many see WiMAX as a progression of WiFi because with WiMAX, the possibility of mobility that was not available with WiFi will be available. WiMAX will come in two forms, but it is the second, the 802.16 rev2004 that will be of greater interest to mobile and wireless operators. Mobile-Fi (802.20) is yet another mobile broadband possibility. However, the 802.20 standard is still behind in terms of specifications and development, compared to the 802.16 and it is therefore unclear whether it will remain in the running for long. WiFi development has continued with the 802.11n, 802.16r and 802.11s which will provide higher throughput, fast roaming and meshed networked possibilities respectively. This has been represented as evolved WiFi in the Figure 24. This development will increase the worth of WiFi and is a possible evolution path to the original WiFi standard.

Table 5 shows the data speeds achievable with some of the technology standards. As can be seen, with each progression to 3G and beyond, the data rates obtainable is increasing, allowing even more bandwidth intensive services to be introduced. Higher data rates have obviously been one of the drivers behind the evolution of mobile and wireless technologies.

Technology Standard	Data Rates Obtainable
GSM	9.6 kbps
GSM/GPRS	40 kbps - 144 kbps
EDGE	474 kbps
UMTS (WCDMA)	384 kbps - 2Mbps
CDMA-One	9.6 kbps to 76.8 Kbps or 14.4 Kbps to 115.2 Kbps
CDMA-2000 1x	144 kbps
CDMA 2000 1x EV-DO	384 kbps – 2.4 Mbps
CDMA 2000 1x EV-DV	3.09 Mbps
CDMA 2000 3x	2 Mbps – 4 Mbps
HSDPA	8 Mbps – 10 Mbps (up to 20 Mbps with MIMO system)
VSF-OFCDM	100 Mbps downlink and 20 Mbps uplink

Table 5. Technology and data rates achievable
Source: (Tan Feb. 2005)

[76] http://www.cdrinfo.com/Sections/News/Details.aspx?NewsId=14245 – cited 051205

A second consideration of mobile network operators as to evolution of their networks was that of their license requirement. There were some regulators in certain countries, which have specified which type of 3G technology platform the operator has to deploy its 3G network on. Because of the stringent requirements that were put forth by the regulators, in such cases, the operators have had to pay close attention to the technology and deployment requirements.

In the early days of network deployment, many areas will likely not have 3G network coverage, but only that of the older, existing network. This means that network operators have to ensure interconnectivity and interoperability between the new and existing network such that different generation of technologies must coexist for some time and operate seamlessly. Roaming agreements will continue to be a part of the mobile and wireless operators means of ensuring wider coverage for their users. As data services pick up, important issues that different networks have to tackle collectively include security, QoS and seamless interconnectivity as well as practical issues such as billing and charging.

Operators will also have considered which technology will provide them with the highest economies of scale. Popularity of UMTS as a 3rd Generation technology exceeds that of CDMA2000. On a global scale, around 60% of subscribers are GSM users. It is predicted that in the future, more than 75% of users will belong to the GSM/GPRS/EDGE/UMTS family of systems (Siemens AG 2002). This means that operators who choose to follow the evolution path to UMTS will benefit from having a large base of users and having many other networks on the same platform will be beneficial as well. The availability of handsets and other mobile terminals suitable for usage under this technology will give network operators more variety to offer to their users. This ready market also ensures that handset manufacturers will supply handsets which are of specifications suited for interoperability between the new network and the existing legacy network. On other 3G platforms, there may not be as many handsets available and thus, these operators will be at a disadvantage.

In deploying a CDMA2000 1x EV-DO network, operators are able to reuse their CDMAOne spectrum. However the move by operators in South Korea in Japan towards a WCDMA network is due to several other reasons. One of the reasons is that with obtaining a licence to operate a WCDMA network, operators were allotted additional spectrum by the licensing authorities. Since the operating frequency of WCDMA is higher than that of CDMA2000, this will enable higher bit rates and thus higher information rates. Another reason for operators to deploy a WCDMA network is to enable easy roaming. The majority of operators in the world now operate at least GSM/GPRS networks. Some have already deployed UMTS/WCDMA networks and others will follow in the next year or two. For operators who have chosen alternative platforms, this poses interoperability problems and also leads to difficulty in setting up roaming services for their users. Therefore, to be able to obtain revenue from roaming users and to ensure service continuity and interoperability, operators such as SK Telecom and Korean Telecom deployed WCDMA networks, which co-exist with their CDMA2000 networks.

On the other hand, we see that not all network operators obtained 3G operating licences. Some have even chosen not to bid for these highly costly licences. Instead, they have chosen to wait it out and to deploy EDGE over their GSM/GPRS network. Since EDGE is able to offer sufficient quality for most data services, it is not necessarily a requirement to invest millions of dollars in licences and infrastructure for 3G networks. EDGE is also seen as part of the evolution path to true 3G networks and therefore a viable solution if the operator does not have a strict licensing timeline, it is possible to deploy EDGE and wait for costs of 3G deployment to decrease or even to wait for 4G technologies to appear in the market. 3G has taken such a long time to move forward, technologies beyond 3G are already in the development process. 4G mobile telephony has already been defined by some and it would allow data rates above that of 100Mbps globally and up to 1Gbps locally.[77] NTT DoCoMo, for example, has been looking Variable Spreading Factor - Orthogonal Frequency Code Division Multiplexing (VSF-OFCDM)[78] technologies for their 4th Generation network[79]. HSDPA and HSUPA are evolutions of 3G that will lead to higher data rates that that obtainable with 3G and this is part of 3GPP Release 5 specification[80].

Something that mobile operators did not take into account several years ago was the appearance and subsequent proliferation of WiFi. WiFi services are increasing in popularity and are considered by some as a cheaper alternative to mobile services. WiFi services, as we know it today, make use of mainly the 802.11b and 802.11g standards, offering 11Mbps and 54Mbps rates respectively. Mobile network operators have seen that WiFi is another possible source of revenue and that there are benefits of combining mobile and WLAN services offerings. Mobile terminals with a combination of access possibilities give users the choice of different network access, depending on various factors like signal strength or price. WiFi development has continued and the further enhancements to the 802.11 standards are being developed. The continued evolution of mobile technology will no doubt take into consideration WiFi and its more recent standards, 802.16 (WiMAX) and 802.20 (Mobile-Fi). These two standards will offer even higher data rates than is possible today and 802.16e will

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[77] http://www.4g.co.uk/PR2004/May2004/2021.htm - cited 051205
[78] http://www.3g.co.uk/PR/March2002/2055.htm - cited 051205
[79] VSF-OFRCDM is said to mitigate the impact of severe multipath interference and thereby achieve a broad-bandwidth, large-capacity wireless system.
[80]Keynote address “Research Activities and Technical Development to 4G” at 5th World Wireless Congress 2004 by Kota Kinoshita. Executive Vice President and CTO, NTT DoCoMo.

include a mobile version of the standard (Drury 2004). Increasingly, technologies that 'bypass' the traditional mobile network are being developed and researched. Mobile operators will have the choice of adopting these new technologies into their service sphere or to carry on with their current technology path and ignore these new technologies and compete against them. In any case, it suggests the increasing number of mobile and wireless technology possibilities and the importance of integrating mobile and wireless technologies onto the mobile device platform.

4.4 Discussion

This chapter has shown that the technologies that were mentioned in the previous chapter all play a part in the development and evolution of the mobile and wireless industry. Technologies can either evolve from an earlier version or they can be revolutionary and be radical technological innovations that could change the market in a disruptive fashion. As we move from 2G to 3G and to beyond 3G, one likely scenario is that of a mixture of different access technologies co-existing together, yet offering users seamless roaming and quality of service. All this would be done through extensive network interconnectivity and terminals offering a multitude of different access types for the user to choose from. Figure 25 illustrates what the future of mobile and wireless communication may be like.

The cloud represents a plethora of access technologies a user may is able to use. Whichever technology the users' mobile terminal connects to could firstly be determined by conditions set out by both the operator or operators involved and the user. After this first configuration or any subsequent change to the conditions of access, the user will be able to seamless roam between different types of networks. This will ensure that the user will never be out of coverage and that he will be continually being connected to the best network. The definition of the 'best network' is of course determined by the conditions that the user had set up. The 'best network' could mean the network with the highest throughput or with the strongest signal strength. Or it could also represent the most cost-effective network choice. This means that contain different access technologies that the user may use when moving from to an area with a different technology, it will make no difference to the service availability and quality that the user obtains.

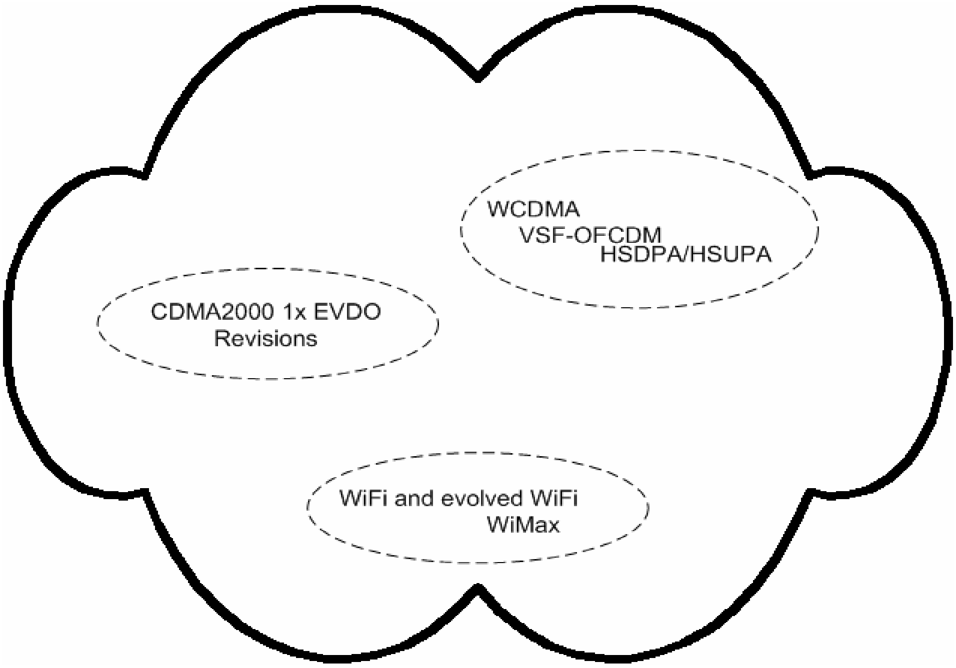

Figure 25. Different types of network accesses coexisting together

There are many technical considerations that network operators and manufacturers alike have to pay attention to. This chapter has mentioned some of the technical issues that have to be addressed and solved as technology moves forward. Many different technical problems or issues exist and these are but a handful of them:

1) Speed
2) Content
3) Network Security
4) Personal Privacy and Security
5) Handoffs, Handovers and QoS
6) Devices

All these and others play a part in the technical development and could possibly affect the uptake of technology when it enters the market. Development of incremental and radical technologies could affect one or more of any of these points. For example, speeds of up to 300Mbps[81] [82] have been reported by NTT DoCoMo in their VSF-OFCDM network tests. This could be seen as an incremental technological change that builds upon the WCDMA-HSDPA-HSUPA evolution path to give higher data rates. On the other hand, WiFi has been seen as a radical technological change. It was originally meant only as an alternative to wired LANs. But as prices of access points came down and WiFi data cards became part and parcel of laptop computers, WiFi became somewhat decidedly threatening to mobile networks as well. WiFi addresses a different market to that of mobile standards. While mobile standards allow for movement, WiFi is a stationary wireless standard that has entered this sector market through provision of services in airports, cafés and even airplanes. WiFi operators have targeted places where users are likely to have time to kill and this became part of the business models of WiFi operators. WiFi would not work in situations that require mobility but it would in situations where the user is stationary. WiFi was considered both a complement and a threat to mobile networks operators. Several mobile operators saw the value of deploying WiFi hotspots on a large scale and to use these to complement their mobile service offering. By adopting a complementary stance in their strategy, they embraced WiFi and offered bundled services to their users. Others took a different stance and choose to publicise and market their GSM/GPRS/UMTS networks further. Their strategy was to continue with UMTS deployment and to concentrate on their core business. Of course, because of the low cost of deployment and equipment, many independent WiFi operators were also able to deploy hotspots and offer pure WiFi services to users. Roaming or network sharing agreements became a common thing within the WiFi operators and users could, on most accounts, use WiFi the world round with one account. The acceptance of WiFi has prompted development work to continue on new aspects of the standard. Areas that are lacking in the earlier standard are addressed with the new versions including aspects such as security, fast roaming and inter-working with external networks. All this work will bring about the evolution of WiFi.

Other wireless technologies such as WiMAX have also gained market share over the past year. Equipment for the fixed wireless WiMAX is already available. WiMAX is considered a real threat to mobile networks such as UMTS networks because it possesses both a fixed version as well as a mobile version. The mobile version of the WiMAX 802.16 rev2004 standard will be able to provide higher data throughputs compared to UMTS presently. Companies will once again react differently to WiMAX, as we have already seen in the case of WiFi. With WiMAX, mobile operators that strategise to make WiMAX a part of the offerings will ensure that they are not left out

[81] http://www.infoworld.com/article/04/06/04/HNntt4g_1.html - cited 051205
[82] http://www.thestandard.com/article.php?story=20040604190846415 – cited 051205

of the WiMAX market. Others will choose not to deploy WiMAX but concentrate on their existing offering.

According to Christensen, a disruptive technology is often introduced by small new companies that have nothing or less to lose in deploying a new technology compared to larger or incumbent players. With WiMAX, we have already seen that small companies are deploying fixed wireless broadband WiMAX solutions. Examples are Danske Telecom in Denmark[83] and Telabria[84] (UK company based in Kent). It is still too soon to tell whether these companies will succeed in the fixed wireless broadband access market but they are the pioneers in the deployment of WiMAX fixed broadband solutions. This is, of course, only the beginning of WiMAX. If predictions are correct, WiMAX development and its growth will continue to increase. At some point in time, larger mobile operators or incumbent mobile operators may seize the opportunity to offer WiMAX as part of their services. Different strategies adopted by different large mobile operators will lead to different acceptance or rejection of a new technology. As with WiFi, some will accept WiMAX readily while others will choose not to and others still adopt it into their mainstream service offering. The business model used with WiMAX will be different to that of WiFi or other mobile technologies. Each technology and market will require dynamic business models with which to succeed.

As technological changes occur with the evolution of different wireless and mobile technologies, it is expected that different companies will react with different strategies in terms of these technologies. When a particular strategy has been adopted, it will then be introduced into the market by following a particular business model. If we look at T-Mobile with their WiFi networks, T-Hotspots, we see that the company, as one of the biggest mobile operators in Europe, decided that WiFi could be part of their company's long term strategy. By deploying hotspots all over Europe and the USA, it capitalised on its share of the mobile market. T-Mobile and T-Hotspots offered independent mobile and WiFi access but also bundled services incorporating mobile, WiFi as well as the use of other T-Hotspots and partner WiFi networks worldwide to users. By adopting WiFi as part of its strategy and then the business model of deploying WiFi networks at chosen locations, the company (as a whole) was open to the complementarity of both products. WiFi, was therefore adopted as a complementary product and one that would sustain their mobile product offering.

The wide variety of technologies that will be available in the near future prompts questions as to whether there will be one dominant technology in the market. True mobile and wireless heterogeneity is an exceedingly difficult task to bridge and to have different networks on equal economic and technical footing is probably not possible. It

[83] http://www.dansketelecom.com/dk/index.htm - cited 061205
[84] http://muniwireless.com/company-profiles/telabria/ - cited 061205

is more likely that there will still be one leading technology and several less dominant or secondary technologies. With the mobile operator being such a principal figure in the industry today, it is difficult to see the future industry without them. The coverage given by mobile technologies as well as the investment that has been put into these gives them an advantage over the other new wireless technologies. Mobile operators and others in the industry will strive to protect their interests and investments and continue to push mobile technology such as UMTS to users. New wireless technologies will probably take a backseat and will be used to fill gaps rather than become the main technology of choice. It is, however, unclear as to what will happen with newer potentially disruptive technologies. As these technologies improve and become more “mobile” in performance, they could, in fact, present themselves as substitutes to conventional mobile technologies and thereby becoming disruptive to the mobile market, as we know it.

5 Evolution of Technologies to 3G and Beyond- Business, Economic and Other Considerations

5.1 Business, Economic and Market Considerations

Today's mobile and wireless industry is one that is made up of big companies with large turnovers and it is certainly of much importance that business and market considerations are addressed with new technologies that are introduced to the industry. There are many technologies, both in the past and present, which could probably have taken the title of the best technology ever invented. However, they never left the research or development lab. The question is why a great technology is unable make a mark with users or to even get known except by a few hardcore techies? One of the most probable reasons for this is that there was no business case or future for the technology or product. Companies that had the product research could find no way to market the technology in an effective way. On the other hand, other not so radical or efficient technologies have made their way into the market. There have also been cases a technology or product invented but never marketed by one company. This same technology or product was later adopted by another company and sold and became a success. How is it that companies miss opportunities with new technologies? How does a company see business opportunities in new technologies and inventions which will affect how technology moves forward?

This chapter looks at the business considerations and other non-technical considerations that are involved in the evolution of mobile and wireless technology. Business and market consideration now play a large part in the success of technology. Different business entities in the mobile industry have different considerations to make while assessing the industry. The network operators and device manufacturers are the most prominent members of the mobile or wireless supply chain and some of the considerations that they have to make while assessing the mobile/wireless business implications of new technologies will be examined. This chapter will also provide further links between technology and business and how closely all these issues inter-dependent with one another in the market. The availability of technology and innovations increases the chances of the industry moving forward but other considerations such as that of business availability and requirements of users will also play a part in whether the industry will change and if so, how much. The strategies of companies will depend much on presented business opportunities and costs of these. The existence of new technologies as well as the business and other factors connected with it will determine strategies of companies and strategies, with the assistance of business modelling will, in turn, determine the disruptiveness or sustainability of a technology or product in the market.

Some of the important business considerations in 3G are looked at in section 5.2. They include 3G licences. The in-depth nature of some of the components here is needed because of the significant economic impact they have on mobile operators. This reflects the discussions with economists and strategists from Nokia and is also reflected in the final report submitted at the end of my stay at Nokia in 2004.

5.2 Important Business Components in 3G

Technology has evolved from 2G to the next generation. However, the uptake of 3G has been slower than expected in the beginning. The number of GSM subscribers is still growing, mainly due to the growing affluence of developing countries in Asian and South America. But, as mentioned earlier, the technology itself is not sufficient to see to the success of a product. A lot of other factors will have to work, together with the technology in order to ensure the product’s success in the market place. Several economic and financial factors have influenced the deployment of 3G and, in general, the revenue of operators. Some of the economic factors that have influenced the evolution of mobile technology from 2G to 3G will be analysed here.

5.2.1 3G licences

One of the biggest financial burdens plaguing mobile operators today is still the costs of 3G licences that they had to pay to obtain 3G spectrum. Operators in Europe paid some of the highest amounts of money for 3G licence fees worldwide. The reason that operators were willing to part with such large sums of money was the potential that 3G offered. It was the typical network evolution path from GSM and GPRS and was considered the next generation of mobile technology. Data services, which are supposed to be the core of 3G, were expected to grow with the introduction of 3G. UMTS licences were expensive. But on top of this, operators had to consider deployment costs of UMTS infrastructure as well as daily operating and maintenance costs. All these financial costs had to taken into account when operators decided to bid for the licences. The total costs of licences and operations would then be factors to consider if the operator wanted to invest in the deployment of other wireless technologies after this. This has also been the reason for the slow deployment of UMTS in most European countries. Table 6 shows some of the licence costs that European operators had to pay for 3G spectrum and Table 7 shows how much was raised in total by the licensing authorities with some of these countries.

Country	Price paid per license	Total cost per head
Austria	US$ 100 million	US$ 90
Belgium	US$ 140 million	US$ 49
Denmark	US$ 118 million	US$ 108
Finland	(Beauty contest)	---
France	US$ 551 million	US$ 4.73
Germany	US$ 7.6 billion	US$ 657
Greece	US$ 125 million	US$ 65
Ireland	(Beauty contest)	---
Italy	US$ 2.01 billion	US$ 203
Luxembourg	(Beauty contest)	---
The Netherlands	US$ 369 – 666 million	US$ 194
Portugal	(Beauty contest)	---
Spain	US$ 111 million	US$ 13
Sweden	(Beauty contest)	---
UK	US$ 6.3 – 9.4 billion	US$ 734

Table 6. 3G license fees in some European countries[85]
Source: (Tan May. 2004)

Country	Amounts Raised from 3G Licenses (US$)
Germany	47.5 billion
France	9 billion
UK	33 billion
The Netherlands	2.49 billion
Italy	10.1 billion

Table 7. Amounts raised from 3G licenses.
Source: [19] and [20]

Building 3G networks is an expensive undertaking and some operators have shared construction costs and network use. This will at least, allow operators to share costs and thereby reducing roll-out and operations costs.

5.2.2 Investments and Sharing of Resources

In addition to costs relating to 3G, certain other investments in existing infrastructure, operations and also research and development had to be considered. Table 8 shows

[85] Source: http://www.umts-forum.org, http://www.itu.int/osg/spu/imt-2000/licensing.html and http://www.cellular-news.com/3G/.

the net debt of several European operators by the end of 2001. These debts were caused mainly by investment in infrastructure and 3G license fees. Some operators have scaled down investments in these areas in order to accommodate 3G. Research and development spending have decreased over the years due to increase in net debt.

Existing network infrastructure and operations will have to continue and work with 3G for some time. Not all customers will switch to 3G in the short run and therefore legacy networks and related operations will have to remain in place to cater to these users. This means that GSM network operators who have bid for and won 3G licences will have two different networks to run for the time being.

Telco	Net Debt (US$)
Deutsche Telekom	58.4 billion
France Telecom	58.1 billion
British Telecom	24.2 billion
KPB Netherlands	20 Billion
Sonera Finland	4 billion

Table 8. Net debt of some of Europe's largest Telco's
Source: [21]

Mobile operators themselves will sign agreements to share network resources and construction costs. There will be roaming agreements, as in the case of GSM/GPRS, allowing users to make use of partner networks whenever they are out of their home network. Roaming agreements means a larger network in which users can make use of services and thereby bringing in more revenue for the operator. Some European operators have been charging very high roaming rates to users but this is now being proved by the European Commission[86]. Partnerships are also formed between operators having only 3G networks with 2G network operators. This will ensure that coverage is available to users who are out of the 3G service. This is a high possibility as when first deployed, 3G services will only cover urban and capital areas. Rural and smaller towns will not have 3G coverage when it is first deployed. To make sure that the user has some sort of service continuity with 2G, roaming agreements will be in place.

The sharing of 3G network resources in some countries has been approved by the licensing authorities to help operators cope with high costs of deployment. With this, operators are allowed to share 3G network resources with one another. Being able to do this defrays some of the high costs involved in full network deployment and at the same time provides coverage by making use of other operator's networks. The

[86] http://news.bbc.co.uk/1/hi/business/4253777.stm - cited 100206

economic problems of operators will be helped with network sharing agreements. The degree of network sharing is determined by each country's licensing authorities and differs throughout.

Yankee Group estimated that European carriers could spend approximately $274 billion to upgrade their networks to 3G (Eastern Research White Paper 2004). This is more than twice the amount spent on licences and is a large investment to make. Operators have therefore looked for solutions in which they can lower costs and one of the ways has been to obtain permission to share networks with other operators in the same shoes; one of which is to share infrastructure costs.

5.2.3 Competition Leading to Loss of Revenue

Competition is likely to increase for 3G mobile operators. When deploying 3G, they will not only compete with other 3G operators but also other operators such as GSM network operators, if they are not already GSM operators themselves. To win customers over to their network, operators will have to embark on aggressive marketing campaigns aimed at increasing their customer base and to advertise their new 3G services. Again, revenue will be spent here. But all this is part and parcel of technological improvement and evolution.

Most operators will have experienced that the revenue obtained from voice calls is decreasing on a year to year basis. Although the volume of voice may not be decreasing, the cost per call is on a downward trend. Due to increase in competition within the market and also the proliferation of VoIP services, traditional mobile voice services have had their revenue cut in some way or other.

On the other hand, the growth of data services has increased revenue in this offering. SMS usage is a popular data service and so is the downloading of tunes to mobile phones. But it is really the increase in other multi-media data services that is assisting in the growth of data revenue for operators. Data services are expected to continue to grow and as 3G moves into a more matured stage, it is expected that more users will accustom themselves to multimedia data services.

5.2.4 Appropriation Concerns in Strategic Alliances[87]

Partnerships and alliances are important part of the mobile industry today and there is not only knowledge being transferred in such practices but also money. Alliances

[87] Some information was obtained from an interview with Risto Savolainen, Nokia Corporation, Salo, Finland, August 2004.

these days, work on a selection of different causes from standardising of interfaces to research and development on technology.

Appropriation concerns in alliances refer to the company's concern about its ability to capture a fair share of the rents from the alliance that it is engaged in. Such concerns arise from the uncertainties, and problems in observing partners' contributions, all of which aggravates the potential for moral hazards (Gulati 1998). Such concerns about appropriation and/or moral hazards occur to varying degree in most alliances because of the difficulty of writing complete contracts. This difficulty is exacerbated when technology exchange or sharing is involved and when the limits of the technology being transacted upon are difficult to specify. The presence of a technology component can affect the extent of possible monitoring problems and the possibility of unobserved violation of contracts. Monitoring problems in technology alliances result from the ambiguity surrounding two key issues: what is the technology being transferred and what are the limits to its use (Bharat and Khanna 1997). Alliances with technology components are complex as partners have to find ways to limit, restrict and monitor transfer of knowledge within the alliance. These may, in turn, lead to concerns about free riding and possible appropriation of key technology by the partner (Gulati 1998). Such concerns are further compounded by the peculiar characteristic of knowledge being commodity being exchanged without the possibility of having complete information on whether or not the partner is exchanging all its knowledge on the area agreed upon (Gulati 1998).

In industry related discussions, theorists often talk about appropriability of rents, usually referring to the ability of firms to capture rents generated by their innovative activities in an industry. Researchers have linked the anticipation of appropriation concerns at the time the alliance is formed with the specific governance structure used to formalize the alliance (Gulati 1998). It suggests that with greater potential concerns, more hierarchical controls will provide greater incentive alignment compared to if there were fewer hierarchical controls (Gulati 1998).

The level of appropriation concerns also stems from the of the appropriability regime of the industry, which is the extent to which firms are able to capture the rents generated by their innovations (Gulati 1998). There are mainly two kinds of appropriability regimes: tight and loose. In a tight appropriability regime, firms can hold on to the profits they earn from their proprietary resources, while in a loose regime; these profits are subject to unintentional seepages to other firms (Gulati 1998). The strength of the appropriability regime of an industry is related to patent strength, the value of first-mover advantage, and the ability to maintain the secrecy of an innovation (Teece 1986). A firm's concern about appropriation within the alliance depends on the industry in which the alliance is a part of; and also the appropriability regime within the industry (Teece 1986). If there is significant patent protection and firms within an alliance consider the appropriability regime to be strong, they are less likely to be troubled by the amount of appropriability within the alliance. This will be obvious in the formal governance structure used within the alliance (Teece 1986).

The benefits of trust in economic or knowledge transactions have been strongly emphasized by the academic world. Trust between firms refers to the confidence that a partner will not exploit the vulnerabilities of the other partners, and is perhaps the most efficient mechanism for governing transactions (Arrow 1974). When there is a trusting relationship amongst partners, there will be greater confidence in the predictability of the actions of the other and this is an advantage when forming alliances as it will result in lower appropriation concerns amongst partners (Gulati 1998). Trust builds interest and awareness within firms on how procedures, routines and rules, as well as how the other partners work (Gulati 1998).

There are countless alliances in the mobile industry with very different purposes and governance structures. As part of the financial development of the firm, most companies will in one way or another, take part in alliances. In most of the alliances, several companies are always well represented. This is of great benefit to the different alliances, regarding the partners almost always having a history of prior cooperation (Gulati 1998). On the whole, industrial alliances are seen as advantageous to the members. But failures in alliances or partnerships do occur, for various reasons. One example is perhaps that of Motorola pulling out of the Symbian alliance[88]. The number of alliances is growing in the mobile industry we will probably see more in the future as this is one arrangement in which development of technology as well as economic benefits could come from. Technological evolution and change would probably be, directly or indirectly, affected by alliances and the contribution from alliances that result in new standards and technologies.

5.2.5 Vendors and Suppliers

One important factor in deciding which technological evolution path to follow is that of availability of related products and services to cater to the new technology. Vendors and suppliers play a main part in establishing a technology in the market. If there are no compatible products, then it is not likely that the technology would take off. Take for example when 3G was first introduced in Europe. Mobile operators, such as Vodafone, complained at that time, that the slow start of 3G was due to the lack of mobile devices from device manufacturers[89]. Networks were ready but the lack of 3G handsets was causing the delay of a much anticipated service. This shows how important vendors and suppliers are to each other in the mobile industry. Even if one

[88] http://news.bbc.co.uk/2/hi/business/3190435.stm - cited 260106
[89] http://www.eweek.com/article2/0,1895,1540436,00.asp – cited 131205

part of the service (in this case 3G networks) is in place, it would not be possible to offer services because another part of the service (in this case mobile devices) is not ready.

The importance of industry support of a new technology will probably, at least partially, determine how successful a technology will be in the market. Vendors, operators and other service providers must be willing to work on technology standardisation process that would lead to products that are compatible with others. Partners will also have to work towards supplying the required products to ensure that the technology take-up rate is not blocked.

As a technology becomes more popular, more vendors and suppliers would be able to offer products and services in this technology. This is advantageous. In the case of the mobile network operator, if more device manufacturers are able to supply high quality handsets, it means that it will have more to offer its users. Also it means that prices will be kept competitively low as the number of products in the market increases.

In the evolution of technology from 2G to 3G, some problems were technical ones, but others were related to the business relationships within the industry.

5.2.6 Market Cooperation[90]

Cooperation and alliances between companies are not a new phenomenon. Since no one company is able to produce everything by itself, it is impossible not to co-operate with others Cooperation is a necessity of industry.

The increase in volume of industrial activity came with new technology and expanding markets. New technology made it possible to increase outputs to an unparalleled level (Tan and Havbo-Kaalund 2004). Improvements in transportation and logistics also made it possible to move goods at faster rates to faraway places. But it is necessary to have a market that is large enough to absorb the increase in output that technology has made possible. It was therefore essential that prospective markets were around. As markets appeared and expanded, these were usually catered to by industries with advancing technologies. Technology allowed for the increase in outputs, which in turn meant that expansion of markets was required to take in the increased outputs (Tan and Havbo-Kaalund 2004).

[90] Some information was obtained from an interview with Risto Savolainen, Nokia Corporation, Salo, Finland, and Paul Melin, Nokia Corporation, Espoo, Finland in August 2004.

The creation of a product and its value chain have been becoming increasingly specialised, due to the fact that more and more companies wish to focus on their core capabilities and therefore choose to outsource their non-core activities. This is because outside suppliers often can apply more specialized skills, and can benefit from economies of scale or scope not available within the firm (Tan and Havbo-Kaalund 2004). It may also be used because adjusting output to variations in demand and maintaining the quality of inputs may be easier via enforcing contracts with outside suppliers than in dealing with a strongly unionized internal workforce. It has proven to be far more effective from both financial and marketing perspectives, for companies to form cooperative strategic alliances than to attempt to go at it alone. By entering cooperative relationships, each company can focus its efforts on those capabilities for which its human and technological resources are best suited (The Chief Executive Dec. 1996). Alliances among companies with complementary resources and expertise spread costs and risks, at the same time that they reduce development time. Furthermore they expand the pool of available and physical resources. Strategic alliances have become common place in many companies' attempts to achieve competitive advantages by gaining market access, scale economies, and competence development through cooperation (Tan and Havbo-Kaalund 2004).

As a result of specialization and the focus on core competencies, there is increasing coordination in the market between the multiple links of suppliers and buyers in the value chain (Tan and Havbo-Kaalund 2004). This coordination is, among others, concerned with the compatibility of the buyer/supplier products; therefore it is beneficial for companies in the same industry that there is some kind of standards to make the company's product compatible with several of buyers and the other way around.

Especially in network technologies it is advantageous for competitors to cooperate on some kind of standardization, because it is crucial that the different manufacturer's products are compatible. So in spite of increasingly intense competition for customers, there is, today, more coordination and cooperation than ever before among producers of goods and services, including cooperation among direct competitors (Tan and Havbo-Kaalund 2004).There exist many different interpretations of what an alliance is. It is commonly defined as any voluntary initiated cooperative agreement between firms that involves exchange, sharing, or co-development and it can include contributions by partners of capital, technology, or firm-specific assets (Gulati 1998). At one end are joint ventures, which involve partners creating a new entity in which they share economic risk and which often have the same hierarchical control features of independent organizations (Gulati 1998). At the other end are alliances with no sharing of economic risk that have few hierarchical controls built into them, typical alliances which have joint learning and knowledge creation as their main purpose

(Khanna et al 1998). Obviously an alliance is a very broadly defined term and is used when referring to different types of cooperation between two or several companies.

Firms differ in the profitability and their conduct but why this is so is something that researchers have questioned time and time again. In answering this question, researchers have typically chosen to view firms as autonomous entities, striving for competitive advantage (Porter 1980). However, this interpretation of atomistic actors competing with one another in an unfriendly marketplace is an increasingly insufficient description. In today's industries, firms are embedded in networks of social, professional, and exchange relationships (Gulati 2000).

An important restriction put on the transaction cost economy has been its implicit treatment of each transaction as separate and distinct events (Gulati 2000). If we looked at the different relationships involved in each transaction, we will see that the transaction in question is part of a history of prior transaction costs and other contractual issues (Tan and Havbo-Kaalund 2004). Social embeddedness between companies results in social networks that enhance the trust between them and thereby being able to mitigate many ethical issues that may occur (Gulati 2000). When one examines the network of relationships in which firms are embedded, one can understand more completely the conduct and profitability of companies (Gulati 2000).

A strong argument in favour of strategic alliances is that alliances provide a company with access to information, resources, markets and technologies, with advantages from learning, scale, and scope economies, and allow companies to achieve strategic objectives, such as sharing risks and outsourcing value-chain stages and organizational functions (Gulati 2000). Alliances also has potential disadvantages such as that it may lock a company into unproductive relationships or prevent the company from forming partnerships with other firms (Gulati 2000). In this way, a firm's network of relationships is a source of both opportunities and constraints. As the economic environment becomes sharply more competitive, the company's network of relationships assumes enhanced strategic importance (Gulati 2000).

5.2.7 Coopetition

Coopetition[91] is a neologism of the words cooperation and competition. It, in fact, refers to business situations and strategies where rival companies, normally competitors for a market, combine to create a stronger product or industry by cooperating with one another (Dowling et al 1996). The reasoning behind coopetition is that if companies only see the world in a "win-lose" competitive frame of reference,

[91] Ray Noorda founder of the networking software company Novell coined the term coopetition in the early 1980s.

they block themselves off from the possibility of “win-win” and cooperative advantages (Dowling et al 1996). A strategy of competing in some arenas, but cooperating in others, offers the opportunity to reap benefits the market may offer to both kinds of strategies (Dowling et al 1996).

Game theory is very useful tool to understand the advantages and disadvantages of coopetition, and how you fully exploit its potential (Tan and Havbo-Kaalund 2004). Stripped to its essentials, game theory is a tool for understanding how decisions affect each other (The Economist Jun. 1996); as the well-known prisoner’s dilemma, in which two prisoners each have two options, whose outcome regarding whether or not to act in pursuit of the group interest, depends crucially on the simultaneous choice made by the other.

Many economists had for a long time, taken for granted that firms could close their eyes to the effects of their behaviour had on the actions of their competitors (The Economist Jun. 1996). This is only true in a true monopoly but where there is competition amongst firms, it does not stand (The Economist Jun. 1996). The theory of Game theorists argues that firms can learn from game players; no card player plans his strategy without thinking about how other players are planning theirs (The Economist Jun. 1996).

In business, as in any game, when there is a victor, there is a loser. But the difference between business and most other games is that in most games the playing field, the players, and the rules are set. In business, the action comes from changing the game (Tan and Havbo-Kaalund 2004). A business game has players and the added value that each player brings. The game is also affected by perceptions – what the players believe. And it has scope of boundaries and linkages to other games – where one game ends, another begins. In reality, there’s only one big game, but that game is so complex that you have to pretend there are a lot of little games and think about how they are connected (Tsai 2002). It is actually possible to draw up a value net – a map of the whole game, the players and their relationships to one another (Tan and Havbo-Kaalund 2004). Money goes from the customers to the business and from the business to its suppliers. Any company’s customers will have other suppliers, and some of those suppliers are going to be good for the focal company in the sense that when customers buy the suppliers products, the focal company’s products become more valuable. These suppliers are the main company’s ‘complementors’; as with Microsoft and Intel. If the focal company’s customers’ other suppliers sell products that make the focal company’s products less valuable, they are competitors (Tsai 2002). The main practical use of game theory is to help a firm decide when to compete and when to cooperate. Broadly speaking, the time to cooperate is when you are increasing the size of the pie, and the time to compete is when you are dividing it up. (Tsai 2002)

5.3 Network Operators and Device Manufacturers

Network operators today are concerned with the decreasing cost of voice services and also how to grow their data centric services. There has been a change in the orientation of business for the mobile network operators to move from a voice centric and voice dominated business to one that offers both voice and data and also value added services on top of these new services. Evolution of technology for the network operators has meant millions, and often billions of dollars of investment into licences for new spectrum, new network equipment and billing and accounting systems.

The device manufacturers, especially those in Europe have had a difficult time in the initial stages of 3G. The slow introduction of 3G in Europe was, as mentioned Section 5.2.5, blamed on the inadequate handsets that were first offered by device manufacturers. In the evolution of mobile technology, device manufacturers have had to integrate more applications and interfaces on the devices to include the ever-increasing number of access types and services on mobile devices. Europe had traditionally been the founding father of GSM and its expertise lay in GSM technologies. 3G meant that there was a shift in technology know-how and therefore new devices incorporating WCDMA technology as well as other accesses had to be designed and built for the new 3G market.

5.3.1 Network Operators

Network operators encompass all types of network operators, from GSM to UMTS to WLAN. Network operators have the function of providing network coverage to users and to provide mobile/wireless services to their users. When it comes to new technologies[92], operators have a significant part to play in their success or failure. Within the mobile industry, different time frames exist for different types of technologies. In the case of network technologies, the time frame for a certain type of air interface to be standardised is much longer than it is for a mobile terminal or handset[93]. The time and effort invested in developing a new air interface is much higher than most other parts of the mobile industry. Therefore, when a new air interface or network type is ready to be introduced and deployed, it could take a long time before they are implemented. This was illustrated in the case of UMTS (WCDMA). UMTS has been in the news for some time and 3G has been has been on the minds of operators and users for a long time. However, when teething problems were finally

[92] From an operator's point of view, technologies will refer to ones that are connected with network access or some other part of the operator's network.
[93] Some statements were obtained from keynote speech at WPMC04 by Dr. Kari Pehkonen, Nokia, "Future of wireless access - evolution or revolution".

solved and the network ready for deployment, it took and is still taking a long time for most operators to roll out UMTS networks. The reason behind this is firstly the amount of licence fees paid beforehand by operators that have caused many, especially in Europe, to delay deployment as much as possible. Also, the large amount of infrastructural costs and operational costs that go into implementing and deploying a new network has also delayed 3G in many countries.

Furthermore, the development and introduction of newer technologies such as EDGE and WLAN have seen operators deploy these initially instead of 3G. EDGE is viewed as an incremental change to that of GSM/GPRS. Therefore, the amount of resources and costs involved in implementing and deploying EDGE is less than that required of 3G deployment. WLAN on the other hand, was at the time of its introduction, a rather novel and new technology. Providing broadband data services over small geographical areas was something that caught on. Airports, cafes and even petrol stations are some of the places that one may find WLAN access these days. Access points were cheap to purchase and easy to install. There were no huge costs of deployment that 3G deployment had and it provided large bandwidths to users.

First and foremost, network operators had also to consider the availability of, good quality data services and applications as well as large quantities of these that could be sold to users. Learning from the mistakes of WAP, network operators now knew that content and services are an intrinsic part of data services, and therefore of 3G[94] (Tan and Havbo-Kaalund 2004). With data being a large part of 3G, large amounts of quality data, content and other types of services are a pre-requisite for success. This can be learnt from the example shown by i-Mode[95] in Japan where it was successful not only because of its technological capability but also users could find a lot of useful and interesting content on the i-Mode sites (Srivastava 2001). Network operators will have to form partnerships and other types of business relationships with content, service and application providers in order that a value chain network is formed and content and other services and applications be made available to users through this network.

Whenever there is a new technology or even continuance of an old technology, network operators have to consider the options that are available for them. One consideration is that of the number of device manufacturers and also platform vendors and other hardware vendors that are going to support the new technology. This is important to network operators because if there are only a few vendors to choose from, it is likely that prices of systems and hardware will be high. However, if there are many vendors supporting a particular technology, it will probably result in lower system and

[94] http://www.uidesign.net/2000/opinion/wapknuckles.html - cited 250804.
[95] http://www.eurotechnology.com/imode/faq-gen.html - cited 230805

hardware prices, and giving the network operator a choice of equipment as well. There is also the amount of standardisation and backward compatibility between the new technology and the old technology that the network operator is already using. Standardisation is an important concept in the mobile and wireless industry as it means more choices for the network operator, such that different parts of systems may be provided by more than one vendor and prices will be kept low in the face of competition. It would not be possible to make a one- off switch to the new technology as users cannot be expected to let go of the old technology at once and to take up the new one. Therefore, as a network operator, it is essential to think about both the supplier and the user of the technology as they are fundamentally related in some ways.

An important business and marketing issue is that of subscription. The question of how subscriptions between different networks will be handled is something to be looked at. This would probably mean changes or the introduction of newer network management systems and AAA systems. As new access technologies make their introduction into the mobile and wireless industry, the number of network operators may also increase, thereby requiring not only that networks be inter-connected, it would also be likely that new subscription methods and usage tariffs be introduced to users. QoS, which was addressed in the previous section, will come with the different tariffs and if rebates or discounts are made with this, then it would probably be a business decision rather than a technology one.

The business model that the network operator chooses to use has great consequence on the overall business strategy of the company. How the operator chooses its collaborators and business partners will depend on its business model. The bundling of services and also of equipment such as mobile devices with network access will play a part in the marketing strategy of the network operator. Different subscription schemes and levels of use would probably continue to be a part of the marketing strategies of network operators as they target very different market segments (from a heavy user to a light user and from teenagers, young adults to the working population and retirees). The availability of a market and whether the users in this market are interested in using or adopting a new technology is also something that the network operator has to consider. If there is a market available and the users in this market is willing to take up the new technology, then it is a possibility that this will steer the network operator in the direction of adopting a new technology. This sort of knowledge can only be known if user preference research is done by the network operator to obtain a gauge of what are the needs and wants of the market.

There are many other non- technical considerations that the network operator will have to look at before it decides to implement and deploy a new technology. Some may be business related decisions and others may be related to the market. All these considerations will play part in the decision making process of the network operator with regards to new technologies.

5.3.2 Device Manufacturers[96]

The device manufacturer provides mobile and wireless devices such as mobile phones, palm pilots and other devices and terminals that interface with the user. Stiff competition exists amongst device and handset manufacturers. Design of new devices with new interfaces that would interest users is something that manufacturers are very much into today and this can be well seen in the number of devices and available in the market.

In recent years, there has been a trend for mobile device manufacturers and their component manufacturers to come together and to form fora or standards organisation such as what Nokia has done wit the Mobile Industry Process Interface (MIPI) and Standard Mobile Imaging Architecture (SMIA). MIPI's main purpose is to accelerate the adoption of application-rich mobile devices by establishing specifications for standard hardware and software interfaces to mobile application processors and encouraging the adoption of those standards throughout the industry value chain. MIPI is essentially a representative of the OMAPI (Open Mobile Application Processor Interface) standardization initiative launched by STMicroelectronics (ST) and Texas Instruments (TI) in December 2002 (Tan and Havbo-Kaalund 2004). SMIA (Standard Mobile Imaging Architecture) is an alliance between just ST and Nokia, which aims to standardize camera modules[97]. ST and Nokia hold the key patents and other intellectual property in the SMIA specification. But these are available to all players in the mobile imaging industry (Tan and Havbo-Kaalund 2004). The reason for device manufacturers to initiate and to join such alliances is that it gives cost advantages, faster time to market and quality components and products. Such standards alliances are seen to be a growing trend as more members of the industry join.

A device manufacturer has a relationship with the network operator in that the network operator is its sole or largest distribution partner. As mobile devices and handsets are often bundled into package deals and included as part of a user's subscription to network services, the relationship here is a long established one. Wholesale agreements and other post-sale services are arranged between the device manufacturer and the network operator.

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[96] Some of the information about MIPI came from interviews with personnel in Nokia Finland during the summer of 2004.
[97] http://www.smia-forum.org/about/ - cited 2400805

When there is a new technology affecting the device manufacturer, such as a new mobile or wireless access technology, there are considerable technical and business related questions to answer before a decision can be made on how to progress. Like the network operator, the device manufacturer will have to consider the potential success of the technology and the market availability and readiness. The number of suppliers that are supporting the technology and also the readiness of networks to deploy the technology are also important business considerations. Before all this, of course, technology related questions of whether it is practical to implement the technology on a mobile device will have to be answered first. But once the feasibility of implementation has been assessed and approved, the business aspects of the new technology will have to be considered.

One aspect for device manufacturers to mull over is that of market segmentation. Working with the network operator as their distributors, device manufacturers will have to provide a range of devices to suit the different groups of users that the network operator is targeting. Different devices with different functionalities and applications are needed to cater to the wide range of tastes in the market. Today, we see mobile phones with the latest functions applications. At the same time, we see mobile phones with the basic phone and messaging functions. This is all done to cater to the different market segments that exist. Some users prefer the basic unit and do not require complicated functions on their device while other users are more technology savvy and appreciate the newest functions and applications on their device. Therefore, knowledge about the different requirements of the market is something that mobile device manufacturers will pay attention to when a new technology is introduced into the industry. Relating to all this is the choice of functions and applications to be included in each device. This is probably very much dependent on the targeted market segment.

Logistical issues relating to the production and distribution of new devices is part of the business process and therefore important when a new technology is being assessed. The device supply chain includes many different partners and the ability of all of them to work together and to deliver the required parts and components for the new technology is something that must be considered. Timing and planning are essential to this process and once again, standardised interfaces and component parts is something to be considered. All this will lead to the device manufacturer having more choices in terms of suppliers and vendors, economies of scale and faster time to market in terms of standardised products. The ability to get the product together is as important as the technology that exists. If this is not possible or if the choices available are not satisfactory, financially or otherwise, then it is unlikely that the device manufacturer will choose to implement the new technology.

The business model that the mobile device manufacturer chooses to use is one that is thought through carefully and thoroughly. There are many aspects of the business model that will differ from that of other industry players. The device manufacturer's business model will take into consideration that its key distributor is the network operator and its alliances with suppliers and vendors. The latter is of growing importance as it is the relationship and business arrangement with vendors and suppliers that would lead to higher volume output sales. Partnership programs and alliances are, as mentioned earlier, a growing influence in the mobile device manufacturer's business model. The strategy adopted by manufacturers will thus be one that gives the largest profit. Having good strategy is about being different and being able to stay on top of competitors (Porter 1996). Any Technological change will result in changes in competition and power within the industry (Porter 1983). For one manufacturer to stay on top of the market is for them to continually assess its strategy. In the wake of technological change, the business model and thus strategy of the manufacturer will therefore have to evolve to meet the new challenges, at the same time, making as much use of the value network that has already been created through prior business arrangements.

The mobile device manufacturer, in the onslaught of technological change will have to consider not only technical challenges that are aplenty in having the new technology integrated and implemented into devices. There are also relevant business and market considerations that have to be addressed, assessing the viability and practicality of the new technology and device. Business relations and alliances play an important part in the manufacturer's business process. Strategies will have to evolve with new technologies and it takes fine balancing between technology, business and market to make the technology work, both for the mobile device manufacturer as well as for the network operator.

5.4 Other Considerations

In addition to the technology and business considerations when the industry moves from 2nd generation mobile technology to 3rd generation and beyond, there are yet other factors that have to be considered. These, together with technological and economic factors, will influence the success and penetration of next generation mobile services.

Other non technology and business issues may also play a part in the future of mobile technologies. As technology evolved from earlier primitive or basic ones to newer and more complicated ones, users too have increasingly become more sophisticated in their knowledge of technology and design. This has led to changes in how humans perceived technology change and also their adoption pattern in view of new technologies.

Social considerations also play an important part in how new technologies and services are taken up. Social conditions such as amount of internet connectivity and efficiency of the telecommunication systems in general may play a part in how well people take to new mobile and wireless services.

The income of a country is also another factor worth considering. Generally speaking, the wealth of the world is increasing as former developing countries become more developed, the average income of these countries will also increase, thereby availing the population to goods such as mobile phones and other related devices and services. The income of the people is determines to the purchasing power and therefore as income increases, so does the purchasing power. When one looks at how technology evolves and how technology is propagated into the population, it is often that the rich or the well-off will start using these services first, even when prices are relatively high. This is the purchasing power of the rich. Mobile device manufacturers have often considered income and purchasing power when addressing different markets. And products that are introduced to developing markets often differ to those offered in developed markets. The more applications and complex a product, the more it costs. The less applications and simple a product, the less it costs. This is one reason why cheaper models are often made for developing markets, as this allows the masses to have the chance to own a mobile device.

The advances in technology in Japan and South Korea have prompted many to wonder why these two countries have managed to get such a high number of 3rd generation users in such a short time. One of the reasons for this is that people here are very willing to try out new types of technologies and products and they are very technology savvy people. They are not afraid to try something new and interest of the government as well as companies in the development of products and services have been very great, adding to the quality of services introduced (Henten et al 2004)

One other factor that is not often considered is that of the country's geography. Wireless and mobile technologies will probably have more use in regions of the world where it is difficult to have wired infrastructure such as cable or optical fibres. This means that these regions will find it advantageous to adopt mobile and new wireless services to communicate with the rest of the world. But it may be that different combinations of mobile and wireless technologies will be used to provide connectivity. Evolution of technologies, the business case of deploying different mobile and wireless technologies will have to be considered. In the cases of countries in mountainous regions and other areas where it is difficult to deploy wired technologies, the evolution of new wireless technologies may be successfully implemented here. But of course, there must be a business case for companies to deploy wireless technologies in these areas. A balance between technology costs and revenue to be earned will be an important deployment consideration.

Government influences are also important in the development of technology and the evolution of mobile technologies. Taking the example of South Korea again, we see that the government and national regulatory body here had influenced the direction of technology growth for a long time. By setting up social policies on the development of the telecommunications and the IT industry, it was able to encourage mobile network operators and device manufacturers to develop new services much faster. South Korea has had a very high Internet penetration rate, and one of the reasons for this could be the fact that South Korea lies on crossroads of the Internet highway, being halfway between the USA and Asia; it has capitalised on its good IT position to help the related telecoms industry. With 3G, the two largest mobile operators in South Korea, SK Telecom and KT adopted CDMA2000 1x EV-DO networks, continuing the evolution from their earlier CDMA network[98]. However, as part of a new policy adopted by the Korean authorities, both companies were also given licences to deploy WCDMA networks[99], thereby creating a demand for dual-band, dual-mode mobile terminals in the country[100].Dual-band allows users to receive the WCDMA or CDMA2000 calls, while dual-mode means it can work in both 2G and 3G networks[101]. By deploying WCDMA networks, the government was, in a way, making sure that Korean companies would not lose out in this technology that was fast gaining ground in other Asian and European countries.

Many different factors have to work together and reach compromises in the growth of the mobile and wireless industry. The industry not only needs to look at technological considerations but those relating to the business and market; as well as those relating to social and 'softer' issues. Evolution of the technology itself is one thing. How the technology can generate revenue for those involved is another- this is the evolution of the business. And how people react and adopt the technology is yet another thing- the social evolution needed to address technology evolution. User requirements are growing in importance and as users become more technology savvy, their knowledge will increase. This will lead to changes in requirements and this is something that has to be addressed by mobile operators and device manufacturers.

[98] http://www.3gnewsroom.com/html/glossary/c.shtml - cited 240106
[99] http://www.3gnewsroom.com/3g_news/nov_03/news_3964.shtml - cited 240106
[100] http://www.telecomasia.net/telecomasia/article/articleDetail.jsp?id=133221 – cited 240106
[101] http://www.3gnewsroom.com/3g_news/oct_03/news_3837.shtml - cited 240106

5.5 Discussion

In 2005, subscriptions to 3G mobile networks passed the 50 million mark (UMTS Forum Sep. 2005). And there were about 33 million 3G (Bienaime 2005).UMTS customers using over 80 WCDMA networks in 35 different countries (Bienaime 2005). As the number of 3G users continues to grow, companies must remember that evolution of technologies comes in stages. Some countries are better equipped to welcome newer technologies and services as compared to others. The individual country's standing in terms of development and wealth are also important points to consider when operators and manufactures alike plan for different markets.

The evolution of mobile technology has come a long way since its humble beginnings. It has grown into one of the biggest markets and in turn has caused the telecommunications industry to evolve as well. Communications used to be of a fixed nature but with the advent of mobile technology, it became normal to have mobility when you make use of a telephone. But to have the technology at hand is one thing. It is another thing to find the market and to make the technology a success. Several other conditions must be satisfied before the true success, which is not based on technology or technological breakthroughs, can be achieved.

Business considerations and the actions of companies take relating to a new technology is one important criterion that will make a technology successful; the evolution of technology to beyond what it is presently will depend on how the companies will adapt themselves to these challenges. The mobile business of today has itself evolved from what it used to be. Previously, before the advent of data services, mobile services were predominantly voice related services. SMS services were the first data service that was taken up by users and has proved to be a surprising success. In some parts of the world, especially in the developing countries such as the Philippines, SMS is still growing in popularity. With 3G, mobile operators are able to offer users much more in terms of data services. Data services such as music on demand and video programs are just some of the services that provide impetus for growth in the 3G market.

In advancing from 2G to 3G, mobile operators and others that have a share in the mobile industry have to consider several factors in terms of business. Some of these have been explored in this chapter. With 3G, many operators in Europe had to pay high licence fees for 3G spectrum. This was detrimental to future operational costs and investments. With the astronomical fees paid by some operators, it severely affected other development areas

Competition will probably increase as we move to 3G and to beyond 3G technologies. Operators who previously did not have GSM licences will add to the fierce rivalry that already plagues the existing mobile market. Competition will come not only from 3G and 2G mobile operators but also from new wireless technologies. In the very near future, operators of wireless technology networks such as those making use of WiFi (and evolved WiFi) and WiMAX will add even more competition to this overcrowded mobile market. Wireless technologies will continue to improve and development work on mobility options is being carried. It will not be long before we see WiMAX and others being able to compete in the mobile market. All this competition will surely lead to a loss of revenue for 3G operators. It will be up to the operators to decide on their strategy for the next phase of the evolution path. As technology evolves, so does the business. The business strategy and the business model of individual network operators will have to change to address the new requirements of the industry. There will no doubt be loss of revenue from existing voice services as costs to users are reduced and also volume may go down in the future, with the predicted growth of VoIP services.

One of the steps taken by different companies in the mobile industry is to form alliances and partnerships. This seems to be the direction of things to come as more and more companies see the advantage of joining related alliances. Appropriation concerns in strategic alliances are well founded as each company would want the ability to capture a fair share of the profits in the alliance that it is engaged in. It will do no good to the company if it contributes more than it can get back from the alliance; to receive something back in return is only fair in an alliance. Alliances are a big part of the mobile industry today. Development and discussions on a wide variety of topics occur within the different alliances and it is quite normal that a company is a member of several different alliances. The level of appropriation concerns is determined on the appropriability regime of the industry, which could be tight or loose. This affects the amount of rents it can procure from the alliance. In order for alliances to truly work, some form of trust must exist amongst the partners of the alliance. Therefore, the importance of alliances to members of the mobile industry is one that grows stronger each day. With alliances, come trust and knowledge sharing and co-development of standards. It is probable that alliances will result in better business practices for firms. In the evolution of technology, it is a credible conclusion that alliances and the business generated by alliances will play an important part in how a new technology is able to perform in the market.

Vendors and suppliers are part of the value chain in any business. In the mobile industry, vendors and suppliers are key figures in the value chain and contribution from them cannot be lacking. To a mobile operator, vendors will provide the technology platform, the operating equipment, and a host of other systems and services. Suppliers of mobile terminals will provide suitable terminals to the operators for sale to users. With 3G in Europe, the slow start of 3G services in Europe was blamed on the lack of suitable terminals from device manufacturers. It can therefore be concluded that one important business consideration when one looks at changes in technology, is that of how well vendors and suppliers work with the providers in the supply of the entire solution to the user.

It is generally accepted that market cooperation between different contributors is needed in the development of products ands services. In the case of the mobile market, there are many different contributors that need to work together to create the technology or the product. And then there are others that have to work towards presenting it to the market. Market cooperation ranges from anything from a buyer-seller agreement to strategic alliances (as described earlier). Competition in the market will mean that companies will have co-operated to get the best cost to revenue ratios. Market cooperation will mean that a company's network of relationships will enhance its position.

When coopetition occurs, the company is in the situation where competitors in a market work together and cooperate to create and market a stronger product. Game theory is often used to understand coopetition and how decisions affect other decisions. In the mobile industry, competitors may work together to create a stronger product or to reduce costs. An example is the sharing of network resources. With 3G, after hefty license costs, several operators have decided to share networks in order to reduce the cost of infrastructure deployment. This is one area where competitors have decided to cooperate with one another. The complex nature of cooperation and highly competitive nature of companies in the mobile industry makes it important to consider where coopetition is useful and beneficial and this could prove to be important as we continue to evolve the mobile business as technology evolves.

Other factors such as the available income of the population as well as its purchasing power are also considered when companies decide how to address the market. The amount of technology advancement in the country and how willing people of a country are willing to adopt and try out new types of technology and services is also a factor to consider when choosing to make upgrades to the original technology. Of course, the technology should be simple to the use but the more technology-inclined the people, the greater the enthusiasm to try new services. The amount of government influence in the development of the mobile market will also play a part in the evolution of mobile technology in the country. The vision of the government will lead the country in a specific direction regarding technology and is something that will also be considered by market players when addressing new mobile and wireless technologies beyond 3G.

From this summary, we see that business and other non technical considerations do play a part in the direction of the industry. How businesses conduct themselves in the mobile industry come in many forms. Different aspects of the business exist and there are many factors that will see to the success of a new technology. The evolution of mobile technology is something that requires, first and foremost a technological innovation that could affect the way the mobile industry develops. Secondly but not less importantly, business considerations have to be taken into account. Partnerships and alliances as well as vendors and the relationships between all these entities are also important in determining how the technology will survive in the market. Other considerations such as social and country specific ones will also play a part in the propagation of the technology outwards into new markets.

6 Standardisation

The advances and changes in the industry have resulted in the need for standardisation. Standardisation is needed to ensure that a product consists of a set features agreed upon by the majority of the industry. When products are standardised, customers are offered a choice of products that they can pick from or the best combination of inter-connectable products. The firms producing these products compete with one another over the range of products available in the market and as the products develop (with standardisation), the prices will decrease while quality increases (Sloep 2002). With technological advancements, standards, too, have advanced since its early form and today, we see numerous different types of standards organisations and standards alliances existing in an ever expanding industry. Standards are said to be a set of technical rules or specifications adhered to by a producer, either tacitly or as a result of a formal agreement and standards come in three forms, as distinguished by Paul A. David and Shane Greenstein (David and Greenstein 1990). They can be reference, minimum quality or interface standards.

With the evolution of mobile technology, so has standardisation of mobile and wireless technologies evolved. To start out with, technology standardisation was taken up by large Standards Development Organisations (SDOs) such as the ITU or ISO. These SDOs worked at an international level with contributing partners coming from industry and academia. Both sets gave valuable contribution to the standards and processes. Later, other smaller SDOs took part in standardisation processes which have shaped and continue to shape the industry. Standardisation within the mobile and wireless industry is a very complex undertaking that requires inputs and contributions from various different players from the industry and also outside the industry (Tan and Henten Sep. 2005). The standards that we use each day are the result of years of research, development and standardisation processes New standards are constantly being formed and refined to simplify industry processes such that they comply with certain criteria, be it technical, operational, economical or otherwise.

6.1 Standard Policies

The setting of different standards for all industries may be done by international agencies, governments or even by market forces. International agencies that set standards do across a global scale and these bodies have to agree to particular standards across a wide range of products and other related matters. Examples of international agencies are those such as the International Standards Institute (ISO) and the International Telecommunications Union (ITU), which is constituted by the UN. The different types of Standards Development Organisations will be looked at further in a later section.

Individual governmental agencies that set up standards do so in all areas where the public's interests are at stake. These agencies may or may not work with international agencies in the setting of such standards. An example of such an agency is the Federal Communications Commission (FCC) in the United States.

Standard policies can generally categorised into being either de Jure or de Facto standards. De Jure standards are those that are officiated by standard bodies and include government agencies, industry committees and also other official standards association. De Facto standards, on the other hand, are standards that are set by market mediated processes (Grindley 2000). The differences between de Jure and de Facto standards are described here.

As mentioned earlier, standards that are set by the market are known as de Facto standards where the standards are a result of competitive forces within each market. These standards are not defined by any formal organisation or governmental agency but set by forces of market such as demand and supply. Of course other reasons than market forces play a part in setting of de Facto standards but these are the efforts of individual companies and do not in any way involve a formal standardisation committee. De Facto standards may be sponsored or unsponsored. Sponsored de Facto standards are proprietary standards and are promoted by one or more sponsors holding some form of pecuniary interest in the standard (David and Greenstein 1990). A de Facto standard may also be unsponsored in which case, as its name implies, no one individual holds proprietary interest in the standard and it exists in the public domain. It is a standard that has gained popularity on its own merit and is adopted by others[102]. Unsponsored de Facto standards are chosen purely on its own merit (be it technical, economical or both). It typically transpires that de Facto standards are set by individuals or groups of individuals working towards similar goals.

De Jure standards, on the other hand are standards that go through an organized process in which a government body or international organisation has a part to play in this process. De Jure standards however may also take two forms: Mandated or Voluntary. Mandatory de Jure standards refer to standards that have governmental legislative links that are related of the country's law. An example is the European Union's Radio Equipment and Telecommunications Terminal Equipment (R&TTE) directive. Voluntary de Jure standards, on the other hand, are used by players of the market on their own free will and not subjected to mandatory legislation. De Jure standards are usually used to differentiate from de Facto standards, which are not developed in any public institutions.

[102] http://www.nationmaster.com/encyclopedia/Defacto - cited 020205

Standards that are developed may be proprietary in nature or they may be open standards. Proprietary standards are those usually owned by a company or a group of companies and are used solely by them. Open standards, on the other hand, are made accessible to everyone. Usually companies with proprietary standards will hold patents and other copyright on their products. Open standards may be developed by one company but have chosen to make the standard available to all. Figure 26 better illustrates the different types of standards.

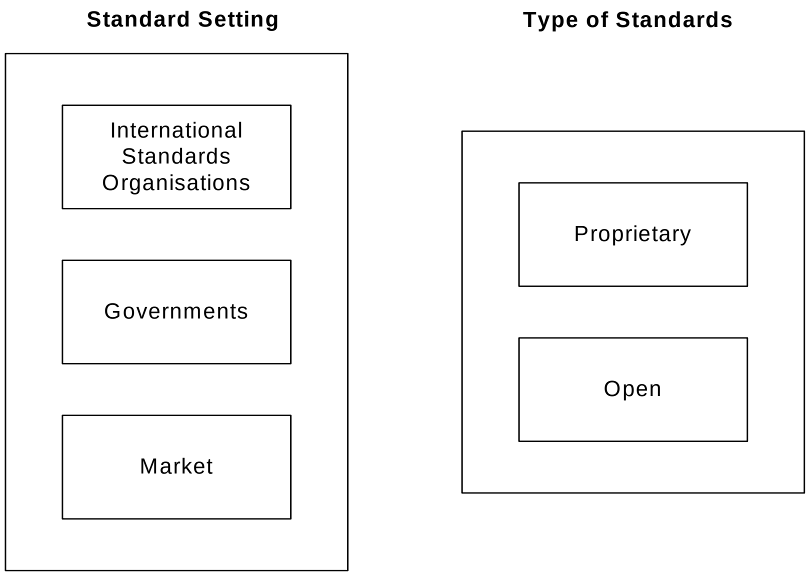

Figure 26. Different standards bodies and types of standards.
Source: (Tan and Henten Sep. 2004)

With the myriad of changes and constant introduction of new technologies, products also go through a standardisation life cycle, so to speak. Early on in the technology life cycle of a product, companies are likely to want to maintain control and proprietary rights over their product or technology. However, in some cases, as the technology or product matures, the company chooses a more open approach to its proprietary technologies[103] (Chesbrough 2003). The reasons behind these are quite simple. Early on in the process, innovativeness in the new technology is of great importance and whichever company is able to make the best out of their technology will have somewhat of an advantage over the others in terms of being the pioneer or being able to develop the technology further at an earlier time. Therefore, in the beginning of the

[103] The author acknowledges that this may not always be the case.

technology product life cycle, companies will tend to have a closed innovation paradigm. As technological expertise flows out of the company to others in the industry due to the mobility of skilled personnel, it results in erosion of the proprietary knowledge held by the original company[104] (Chesbrough 2003). As a result of this, it is therefore in the interest of the company to handle its proprietary knowledge in a more open way, following an open innovation paradigm (Chesbrough 2003). “Open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. This paradigm assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology” (Chesbrough 2003). As the technology is soon adopted by others or once other companies have the time to work on and develop the technology further, it is to the advantage of the company to open up its technology, so that others may work on it. One way to do this is by engaging in joint partnerships or alliances to develop the technology further. This will increase the output and, therefore, the efficiency of the system. By doing this, the company is giving the message of openness and a willingness to cooperate for the sake of improving the technology or product. By this time, it is likely that the company has achieved some share of the market and can well afford to engage in alliances to share part of its technology and development with others in order to promote compliance and standardisation in parts, components, interfaces, etc. Therefore, in the onset of an innovation, proprietary technology is usually kept in a closed innovation paradigm, but later on, open innovation paradigms could enable the company to succeed and progress further.

Another way of engaging in an open innovation paradigm and not to lose out on revenue is to grant patent licenses to others. Patents, which are short-term monopoly rights (typically 17 years in duration), are granted by the government to encourage the dissemination of innovation, are revenue generating in their own rights. If a company is able to generate revenue through the licensing process, i.e. engage in rent-seeking, it would not want to relax its proprietary position. Viewing this as a business matter, if it has a lot to gain from licensing fees, then a company would want to withhold access and charge others who use its technology in order to maximize its own revenue, rather than sharing the information and knowledge with others through alliances and partnerships. The inherent tension between patents, licensing and profit creation is usually reconciled by legal and regulatory authorities. This is done by making a determination as to what constitutes reasonable value to each member.

[104] It is noted that erosion may be protected by contractual agreements such as non-disclosure agreements between the company and the employee.

6.2 Standards Organisations

Different types of standards organisations or associations exist in today's mobile and wireless world. International organisations such as the International Telecommunications Union (ITU) were established to look into the standardisation of telecommunications and other communications technology and policies. The ITU was to be an "impartial international organisation within which governments and the private sector could work together to coordinate the operation of telecommunication networks and services and advance the development of communications technology"[105]. The ITU is a part of the United Nations and is therefore considered the "pre-eminent global standards developer for telecommunications"[106]. The activities that the ITU is engaged in are therefore generally in decision making and policies involving governments.

Next, there are regional standards organisations that work in one region of the world and one good example is the European Telecommunications Standards Institute (ETSI). ETSI works in the European region to ensure regional synchronisation of developmental work of standards amongst the member countries. It also assists in aligning work among countries in the region.

A third type of standards organisation works on a national scale. These exist mainly in Europe where they are now trying to sustain their existence in industries where regional and global organisations are taking over (Tan and Henten Sep. 2005).

Finally, there are there are industry fora. These are comparatively new additions to the standards community and are mainly made up of industry companies. Some fora and consortia work on a global basis when it comes to producing technical specifications. Large and smaller companies come and work together and towards the standardisation of certain processes/parts within the industry. In the mobile industry, good examples of these are the IETF, 3GPP and 3GPP2 fora. The 3GPP and 3GPP2 are working towards standardisation in 3rd Generation wireless technology, services and applications. While 3GPP has been looking at the standardisation of mobile technology evolved from GSM, the 3GPP2 has been looking at the standardisation of mobile technology evolved from the CDMA family of standards. Members are companies that have a part to play in 3G such as mobile phone manufacturers and technology platform vendors (Tan and Henten Sep. 2005).

Table 9 shows the different types of standards development organisations and descriptions of their characteristics.

[105] http://www.itu.int/aboutitu/overview/purposes.html - cited 050905
[106] http://wireless.ictp.trieste.it/ITU_workshop/lectures/passerini/Passerini_12.pdf - cited 191205

Type of SDO	Characteristics	Examples
International	large body overseeing important aspects of technology such as frequency allocation	ITU, ISO
Regional	regional standards body overseeing standardisation on a regional basis, with different national governments working together	ETSI, ARIB
National	National agency looking at standardisation within each country	BIS (UK), AFNOR (France), ARIB (Japan)
Fora	Groups of companies, usually working internationally on standards	OMA, 3GPP, 3GPP2

Table 9. Different SDOs
Source: (Tan and Henten Sep. 2005)

As mentioned earlier, it seems to be a growing trend that industrial standards organisations and fora will play a larger part in the future of standardisation within the mobile and wireless industry. There can generally be two different consequences of industrial fora or industrial alliances.

The first would be that such alliances will provide the basis for working together and stimulate innovation between the partners working together on technology development. This is a form of the positive social consequence that results from alliances and other standards bodies. With different partners working together, economies of scale in the production of equipment and components will reduce costs and increase availability (Gandal et al 2003). All this can be achieved at a faster rate and the danger of monopolies is minimized since technologies are documented and open to all players (Dutkiewicz et al 2005).

The second consequence could be just the opposite; that innovation is stifled because of the competitive nature of companies working on similar products and technology. Being in an alliance or working in a standards organisation means that you work within the limits and boundaries set by the companies involved. Participants will therefore have to work under the strict orders of their company and this includes the amount of information to be shared with partners. This could, in turn, lead to stifling of innovation and to new technological developments of potentially newer and better technologies and products. There will have to be a balance in the amount of innovation that comes out of industrial alliances and the amount of protection that each company will have on its own technology development. According to Hamel, Doz and Prahalad, companies must be able to “use competitive collaborations to enhance their internal skills and technologies while they guard against transferring competitive advantages to ambitious partners” (Hamel et al 2002).

The goal here is to have a faster time to market with interfaces and components and to have more competition within the industry, and thereby being able to pass on lower costs to customers. Large global and regional standards developing organisations have processes in place for standardisation activities and these usually take a much longer time that would an industrial forum. Therefore, the likelihood of more standardisation activities being taken over by organisations such as the OMA and MIPI is quite high (Tan and Henten Sep. 2005). These organisations look at standardisation of interface or compatibility.

6.3 IEEE- SA

Today there are many standards organisation working in the mobile and wireless industry to develop standards. One interesting SDO to look at is the IEEE-SA (Institute of Electrical and Electronic Engineers- Standards Association)[107]. The IEEE-SA, which is based in the USA, used to set standards based on individual standards development programs. In the past, individual members who had the technical know-how contributed to the standards process. However, this has changed in recent years to include industry participation. This is a membership based organisation that has contributing partners from industry, government, universities as well as individuals. Standards go through vigorous technical development and balloting by qualified members will decide on the outcome of a particular standard. One of the most popular standards developed by the IEEE is that of the 802 Local and Metropolitan Area Network Wireless and Wired standards. The following describes how standards are developed within the IEEE- SA. The following information was obtained from the IEEE standards operating manual and the IEEE-SA website on standards development and participation (IEEE Standards Association 2006) (IEEE Standards Association 2005).

To initialise the standards development process, a potential project idea will have to be filed. This idea is known as a Project Authorisation Request (PAR). This would be sponsored by the IEEE society which has interest in the content and scope of the proposed project idea. Of course, more than one IEEE society may have an interest in the project. In this case, the idea will be sponsored by a Standards Coordinating Committee set up by the IEEE Standards Board. Before the PAR is granted, the IEEE Standards Board will have to establish if there are enough volunteers to develop the new standard.

The outcome of the development process is a document. There are several possibilities to the contents of the document:

[107] http://standards.ieee.org – cited 140405

1) Mandatory requirements
2) Recommended Practice
3) Suggestions for working with a technology (guidebook)

The IEEE Standards Board will have to approve a PAR based on a review by its New Standards Committee. During this review, it is possible that a PAR is not approved. There is a time frame of four years within which a standards project should be completed. When a PAR is approved, the initial study group then becomes a working group. Working groups are open to the public. Therefore, both individuals and companies that would like to contribute are welcome to join a working group. There are procedures regarding membership, voting, officers, recordkeeping and other areas in which people can contribute to. Each working group will publish its meeting minutes to promote openness in development.

After the working group has worked on the standard, the sponsor will form a balloting group which is made up of people who are interested parties. This will only happen when the sponsor decides that a draft of the full standards is good enough to be presented at a ballot. During the ballot meeting, anyone can contribute with comments and suggestions. But voting towards the approval of the standard is only done by eligible members of the balloting group. The balloting is a fair event and the balloters consist of different members of the industry, from producers to consultants to the general user and government officials. The process of balloting lasts from one to two months. A standard will pass if at least 75% of all ballots from a balloting group are returned and if 75% of these approve of the standard. Comments made during the process will be answered by the ballot resolution group.

Recommendations from the Standards Review committee will assist the IEEE-SA Standards Board in its decision to approve or to disapprove a standard. The Standards Review committee has the duty of overseeing that working groups follow all procedures and guidelines in drafting and balloting of a standard. When the IEEE-SA Standards Board has approved the standard, a Board editor will edit the standard and have a final review the members of the working group and finally, the standard will be published. Clarification or questions on the standard may still be submitted after the standard has been approved. These and the answers from the IEEE-SA will be published on the IEEE-SA website.

Amendments to standards take place all the time. A standard is in place for a period of five years from the date that it is published. During this period, a working group can further develop the standard and ballot revisions are held to extend the standard. Once the five years are up, the standard will have to be reaffirmed, revised or withdrawn by the committee. At this time, the standards document is open to all comments and once it is approved again, it will remain in force for the next five years before the next review. If the standard has to be revised, it would need PAR process and follow the earlier mentioned balloting process until the Standards Board approves of the standard. If the standard is thought to be too old or out of date, it can be withdrawn. Again a balloting process is used to establish the Standard's withdrawal.

As we can see, the IEEE Standards Association has a well tuned standards development and approval process in place from the very many standards work that it has taken part in its lifetime. Processes like those examined here will likely be similarly mirrored in other standards organisations or associations in the formation or development of new standards.

6.4 The 802.11 Standard

One interesting standard that has been developed and is still being revised is that of the 802.11 for Wireless Local Area Networks (WLANs). The IEEE 802.11 committee was set up in 1990 to get the wireless standard going but it took 8 to 9 before the standard was published. The 802.11 was rectified into the 802.11b (which operates in the 2.4GHz band) and the 802.11a (which operates in the unlicensed 5.3GHz and 5.8GHz band).

With the growth of high speed internet access in the home and office, the popularity of WiFi took off and devices were available at low prices. The proliferation of hotspots in places such as cafes and airports also added to the growth of WiFi as a public service.

Table 10 shows some of the more popular 802.11 standards that have been developed and/or are still being developed by the IEEE.

Standard Name	Description of the Standard	Speed Supported	Operating Band
802.11	Orignal WLAN standard	1Mbps to 2Mbps	
802.11a	High Speed WLAN standard	54Mbps	5GHz band
802.11b	WLAN standard	11Mbps	2.4GHz band
802.11d	International Roaming (Automatic configuration of the device to meet local RF regulation)		
802.11e	Addresses QoS requirement for all IEEE WLAN radio interfaces		
802.11f	Defines inter-access point communication to facilitate multiple vendor-distributed WLAN networks		
802.11g	Establishes an additional modulation technique	54Mbps	2.4GHz band
802.11h	Defines specturm mangement		5GHz band
802.11i	Addresses the current security weaknesses for both authentication and encryption protocols. (Encompasses 802.1X, TKIP and AES protocols)		
802.11n	Provides higher throughput improvements	500Mbps	
802.11p	Wireless access for the vehicular environment		
802.11r	Fast roaming		
802.11s	Defines wireless meshed networking		
802.11u	Interworking with external networks		
802.11v	Wireless network management		
802.11w	Protected management frames		

Table 10. Description of the 802.11 Standards[108]
Source: (Intel), (IEEE 802.11 WG May. 2004), (IEEE 802.11 WG Aug. 2004a), (IEEE 802.11 WG Aug. 2004b), (IEEE 802.11 WG May. 2005).

The standardisation of the 802.11 standard and its many revisions has been the result of its constant growth and popularity of wireless access and also potential of the technology used, such as OFDM and MIMO. The technology is constantly evolving towards the next generation. The earliest 802.11 standard was not sufficient for broadband purposes. So the 802.11b standard was specified to address this and it could support up to 11Mbps in the 2.4GHz spectrum. This is the licence free spectrum which means that it is cheaper to produce devices compared to the licensed spectrum because a premium is charged for exclusivity. At the same time that the 802.11b standard was created, the 802.11a standard was, too, being specified. But the 802.11a works in the 5GHz range and it supports even higher data rate at 54Mbps. Because the 5GHz spectrum is licensed, it means that 802.11a devices would not be as cheap as 802.11b devices. The later 802.11g standard combined the advantages of both the earlier versions. It can support up to 54Mbps bandwidth at 2.4GHz and is therefore backward compatible with the 802.11b standard. The latest 802.11n hopes to provide even higher throughput of up to 500Mbps. This would operate in the 2.4GHz spectrum and would therefore be backward compatible with both the 802.11b

[108] Source: http://en.wikipedia.org/wiki/IEEE_802.11 and http://standards.ieee.org/getieee802/ cited 200106

and 802.11g standards. Other 802.11 standards deal with improvements on other aspects of the technology such as roaming and handover and also lately, of being able to have meshed networking within the 802.11 standard.

The 802.11 standard is one that has been under development for a long time. It has changed and evolved to suit the needs of the market. This standard was once thought of to be a challenge to 3G as many operators saw WiFi as a cheaper alternative to rolling out 3G which was both costly and complicated. However, these days, WiFi is seen more as a complementary product to 3G and other mobile standards than a competitor. The standardisation process for 802.11 constantly progresses as the industry progresses. In its early days, the 802.11 standard could be well viewed as being a disruptive technology. This was because it was thought to be a replacement to 3G. However, WiFi has, actually been adopted as a complementary product. In fact, WiFi has become a somewhat complementary product to GSM and UMTS. Mobile operators have been making use of the popularity of WiFi to increase their revenue. WiFi addresses a different market to that of UMTS or GSM. Even though users may overlap, the target use of WiFi is different to that of mobile networks. From an abstract point of view, this could lead to the conclusion that WiFi is a disruptive technology (Refer to Chapter 2). However, the conclusion could also be that the different technologies complement one another (Tan and Henten 2005). Technology determines the amount of radicalism or incremental changes in a particular technology or product while it is the market that really determines the disruptiveness or sustainability of a technology or product. The case study of WiFi in Section 6.10 looks at the 802.11 standard in more detail.

6.5 Appropriation of Profit versus Setting a Standard for the Market

In recent years, some companies have put in a lot of effort in standard setting as part of their long term strategy for revenue maximisation. That is to say that these companies believe that setting the industry standard and market share is more important that that of profits. Whether this decision is forced or by choice, it is a phenomenon that is seen in today's market place. This may be explained by the concept of the dominant design (Refer to Chapter 2) (Anderson and Tushman 1991). In the markets of today, most products that are introduced to the public are products that have converged to a dominant design or at least in the process of becoming a dominant design. After a product has reached a dominant design, some products will continue to evolve and standards based on technical specifications will be established (Grant 2001). This is the standardisation process that some products will go through when becoming an industry standard.

In his book, Robert Grant (Grant 2001) states that network externalities exist when the value of a product to one person is dependent on the number of other users of the same product. The product does not have to be the same in terms of physical features or technology but they have to be compatible with one another. In turn, network externalities create positive feedback, creating the largest customer base for the most popular or widely used product manufacturer. This will result in a standard being set by the dominant product manufacturer. Once set, standards are usually not easy to dislodge. This leads us to the theory of Path dependence which, defined by Brian Arthur (Arthur 1989) is related in terms of “lock-in by historical events”. This means that the decisions made earlier will affect decisions to be made in the future. Once a standard is adopted by the masses, it will be difficult to dislodge. Path Dependence arises once a technology is adopted as a standard and future newer technologies will find it difficult gaining a foothold where this standard has already managed to lock-in the industry to the earlier standard. The emergence of competing standards in industries (such as those found in the electronics and communication industries) has resulted in what is known as standards wars.

In today’s mobile industry, having open standards are the goal of organisations such as MIPI. By promoting standardisation in the mobile processor interfaces, the companies that formed MIPI are encouraging other companies’ participation in this organisation in the hope that knowledge sharing will occur. It also hopes that by having standardized interfaces, there will be a larger supplier and co-operation base. If interfaces are standardized, manufacturers of mobile terminals such as Nokia and Sony Ericsson will, theoretically, have more suppliers for parts and modules that interconnect with these standardized interfaces. Having more partners working together on standard interfaces will also mean that products will have a faster time to market. With standardised interfaces, less time will be wasted with looking for suitable connectable modules and thus time from R&D to production will reduce significantly. This, however, brings up the problem of collusion or a pact between two or more companies engaged in alliances and how they could, with this alliance, control the industry or parts of this industry.

In the past, we saw the battle between Sony’s Betamax and JVC’s VHS format for video recording tapes, which resulted in JVC winning the market. The reason for this was that JVC did not insist on full ownership of the technology and opened its technology to other manufacturers through licensing and thus increased the product adoption rate in the market. Sony, on the other hand, had very tight licensing and ownership protection of their technology and was not able to gain much support for their product because of this. It can be seen that by having a more open standard, JVC was able to gain early support for their product and thus was able to be the standard of the VHS recording market.

Another classic example is the standards war between IBM and Apple. Here, IBM was successful in setting the industry standard by not restricting access to their technology, and thereby allowing others to 'copy' its product specification, and resulting in a large number of Original Equipment Manufacturers (OEM). Apple, on the other hand, kept access to their technology only to themselves. The result was that Apple was able to gain high margins in the beginning but because of this tight control over its product technology and architecture, they lost this in later years. Another factor was incompatibility of their later systems with their original product. IBM, however, was able to set the industry standard for a long time but because they did not own much of the Intellectual property to their technology, they were not able to generate much revenue from it. Therefore we see that neither path is the ideal one. Companies should strive to obtain a position somewhere in-between to reap the benefits of both sides.

An example in today's mobile/wireless industry is that of WiMAX (802.16) versus Mobile-Fi (802.20). Both have the ability to be replacements for broadband access. In other words, last mile connectivity, it would be able to replace cable or DSL technology with these broadband fixed wireless technologies. Very large industry players originally backed both technologies. While the mobile industry has been accepting of WiMAX, they have not been as accepting to the Mobile-Fi technology, which they see more as a threat to their business than a complementary product as WiMAX (Gabriel 2003). But Mobile-Fi is way behind in development compared to WiMAX and this is seen as a disadvantage. As we have it now, the two standards are competing for the new market and it remains to be seen what the outcome of this will be.

In any standards war, there are several requirements that should be fulfilled before a company decides to 'take over' the market. These are as mentioned by Shapiro and Varian (Shapiro and Varian 1999). The first is to gather your allies. These allies may be competitors or supporters. But support from others in the industry is a very important asset to have in any standards war. The second item is market pre-emption. In order to do this, the company will have to enter the market early and obtain an early lead that allows positive feedback to be advantageous to the company. The company that enters the market earliest will have a better sense of what customers want. Lower prices to make products attractive to first users are also an important part of market pre-emption. However there is always the chance that the first product to enter the market will be flawed and this may affect customer adoption. The third requirement is to manage expectations. Expectations of both customers and also suppliers and producers of complementary products should be somehow managed. To suppliers and producers of complementary products, signals that the product to be introduced will be successful should be given to gain support. To customers, pre launches to make the product known to them and to gain publicity. In this way, when the product is launched, customers will have an idea about it and will want to try it out.

In trying to set standards in any market, it is often very difficult to find a balance between appropriations of revenue or profit and gaining market share in terms of a standardized product accepted by the masses. To be able to profit from standard setting, a company must firstly set the standard, and secondly retain some proprietary interest in the standard in order to appropriate some revenue from it. However, it has been known and has been seen in the previous mentioned example of Sony versus JVC for the VHS standard that the more a company tries to keep proprietary interests and appropriate value from its product, the more difficult it will be to build support and hence set a true standard in the market with that product. Therefore, for companies considering one or the other, it is a very fine line to tread. Profit is not proportional to being the dominant product or standard and therefore this is part of the reasons why today, many technology companies are adopting policies of open standards in order that easy access is given to others in the industry (either competitors or complementary product manufacturers or suppliers). This is done to gain greater market share in order to set the standard for that particular industry.

Standardisation is important in creating products that are compatible and also to share information about technology. However, it is also important that companies are able to appropriate revenue from the technology or product they develop. To find the equilibrium position in the mobile industry between appropriation of revenue and standard setting is a difficult task. Companies today are working towards similar goals and see the advantages of working together in reaching their goals rather than against one another.

6.6 Standardisation for the 3G market

Standardisation, as mentioned earlier may be de Facto standards or they may be de Jure standards. De Facto standards may take the form of being sponsored or unsponsored. De Jure standards can be voluntary or mandated.

The standardisation process that took place for 3rd Generation mobile telephony was a long, drawn procedure that was in fact a global standardisation development. With 2nd Generation networks, GSM is the dominant standard that is used in Europe and most of Asia. Operators in the United States also deployed GSM. CDMAOne, the next popular standard was deployed in South Korea, Japan and also in the United States. As we can see, although GSM was the dominant standard, it was not a fully global standard. In this respect, 3G was seen as a means to address this issue and policy makers wanted to come up with a uniform standard that was accepted and used globally. This is of course easier said than done. Spectrum allocation alone is a complicated matter with different countries having used different sets of frequencies for different purposes. To align this globally would have caused massive confusion and disturbances. So, as a compromise, a family of standards was adopted under the IMT-2000 program and the two major standards competing here are WCDMA and CDMA2000.

In the United States, very often the approach to standardisation is distinguished by a decentralized bottom- up dominated approach, which relies heavily on market forces to decide what the standard in that market should be (Dalum et al 2004). With 2G, there existed GSM, CDMA as well as TDMA systems that were deployed by different operators in different states. This can be said to be the work of letting the market decide which is the best standard to adopt. When no concrete decision is made, different standards will co-exist. Although this led to the American mobile industry being slightly less advanced compared to the European industry, it does show that such a policy is possible and non-intervention by standards organisation can also work.

Standards setting in any industry are a complicated process, and a good example is the standardisation process that resulted in Europe choosing the WCDMA technology over CDMA2000. The deployment of UMTS networks (based on WCDMA) in Europe is largely based on political and strategic influences. Although the ITU (International Telecommunications Union) had started work on 3rd Generation specification in the 1980's, real development of the standard did not really take place until much later. As industry activities at that time was mainly centred on rolling our of the GSM network and on making a profit on this investment, not much work was actually concentrated on the technical specifications of 3G. The ITU actually did not have an active role in the decision making process for 3G standardisation. At an international level, much of the standardisation work was conducted by the 3GPP (3G Partnership Program) and 3GPP2 (3G Partnership Program 2), which was largely made up of players of the mobile industry such as equipment manufacturers and mobile operators. Other regional standardisation committees also played a role in the two programs. The ITU mainly held a co-ordination role with respect to the IMT-2000 project and also on spectrum allocation issues with the WRC (World Radio Conference) (Saugstrup and Henten 2004).

The European Telecommunications Standards Institute (ETSI) was formed by the then European Union to ensure a standard mobile telecommunications standard across Europe, which had not existed before GSM. The members of ETSI are firms, telecom operators and others (Grindley et al 1999). This, of course, makes the decisions making agenda based on their economic strategies. Europe makes use of standards bodies or standards organisations backed by government mandated single standards for most standardisation processes (Grindley et al). This is advantageous in obtaining a fully uniform standard across the continent. However, because of strong industrial participation involved in the standardisation process, it sometimes happens that not the technically most efficient or cost efficient technology is chosen. In comparison, the American standardisation based on market forces ensures that the best technology is chosen and there is fair competition among different complementary standards.

In the EU, work on 3G started with several projects: RACE I, RACE II and ACTS. The findings and results from the ACTS program were then submitted to ETSI as a candidate for UMTS and to the ITU as an IMT-2000 submission. From the beginning, equipment manufacturers Ericsson and Nokia already favoured WCDMA, which was one of the air interface standards submitted to ETSI. The voting processes involved in ETSI concluded in their favour and WCDMA was the chosen air interface standard for UMTS.

As compared to 2G, 3G (UMTS) offered much more technologically challenging and the standardisation process for 3G was an even more complicated process. With more at stake for all market players, their role in the standardisation process was more weighted than previously. The 3GPP and the 3GPP2 organisations are such examples. With 3G, however and now with newer technologies, there is more industry participation in different standardisation programs. While some of these standardisation programs still have a governmental influence, most of these have been set up by industry players and are formed without any influence of standards/government organisations. This leads to the formation of a new type of standard being formed, which can be viewed in some cases as being sponsored de Facto standards. And when there is some link with a standards organisation, they can be viewed as voluntary de Jure standards (Oest and Henten 2001). ETSI and other standards development organisation are known the world over as being strict with the proper enforcement of standards and other processes. Companies support organisations like ETSI in order to give credibility to their standard to ensure its success is linked to impartiality or objective criteria. However, neither sponsored de Facto nor voluntary de Jure really gives a good enough description to the standards alliances and organisations of today's mobile industry, where competing manufacturers come together in order to produce standard technology for the mobile devices of the future, as they do in the MIPI alliance. The WAP forum is another example of such a standards organisation.

It may be a trend that we see that standardisation processes for beyond 3G or 4G technologies will be even more complicated than they are today. Industry centred standards alliances and organisations will have a big part to play in these processes. Governmental agencies and international standards organisations will still have a part to play in standardisation processes in the future but perhaps with a more high level view, while leaving technical specifications and standardisation to industry players.

Also, with the advent of less regulated wireless alternative technologies, the growing requirement in mobile/wireless devices is ever growing. All stakeholders in the market will have important roles to play with future generation of mobile/wireless services.

6.7 Advantages and Disadvantages of Standardisation

Standardisation processes are seen as Janus-faced. On one hand, it is seen as means to getting processes and technologies aligned and see to compatibility of different products and interfaces. On the other hand, it is seen as an obstruction in the development of new innovative technologies as companies and individuals concentrate on those undergoing standardisation processes. Some of the advantages and disadvantages of standardisation will now be looked at.

SDOs and the standardisation process give members a common goal within the organisation. Standardisation allows companies and other industry members to synchronise development activities in a particular direction as well as to harmonise technology development with government representatives and related industry representatives. This means that members of an SDO are able to work towards a similar goal and thereby cooperate and reap gains from this cooperation.

With standardisation of interfaces, equipment and products following the standards specifications will be compatible with other products that have also been standardised accordingly. When products are standardised, it usually means that they meet a certain criterion and will therefore be widely accepted. This means that a user will have a wide range of different products to choose from and does not have to limit itself to one or a few vendors. Standardisation will give users the opportunity to choose amongst different vendors for different parts of a system. When products are standardised and companies adopt the standards into products, it means that there is likely to be a number of vendors and suppliers of similar products. With this, it is likely that prices will be competitive as vendors strive for economies of scale with their products.

Work on standardisation brings together different industry members, who may be collaborators or competitors outside the standards organisation. For companies to work together on standards, many different reasons exist. Some are in it for to acquire new technologies or skill sets, others are in it to reduce costs of their own operations and to seek new profits from the cooperation.

The continual nature of the standardisation process is an attractive feature as it ensures that in the long run, older and more mature specifications will be re-looked at some point in time. A renewal of technology is undertaken as part of the standardisation process. This will result in the evolution of the older technology to something newer and more attuned to a new market and this will be worked on by different members of the standards community.

One of the criticisms of standardisation is that it may in fact be suppressing innovation by individuals and individual companies. As the path chosen in development of a particular technology will allow for small changes, it is unlikely that radical changes and innovations in technology will be taken into account once the standardisation process has started. This means that better, more efficient technologies will be left out, simply because they were not part of the specifications of study or development in the standards development process.

Committee based standards, such as those that are developed by the IEEE or ETSI, where many large industry partners work on development work, may in fact suppress innovation. Proprietary standards that are better, technologically speaking, may not be as popular (because they are not endorsed by internationally renowned standards groups) and may not gain market share due to the fewer number of vendors and suppliers. Therefore, the development of newer and radical technologies within industry standards organisations may not be as substantial as if the standards were developed as a proprietary type standard within an individual company.

There is a constant battle to achieve the right balance between appropriation of revenue and standard setting. Different companies have different agendas for participating in alliances and other standard setting organisations. And how much a company can really get out of such an organisation is an important consideration to how much it shares. The issue of Intellectual Property Rights (IPR) is also a growing concern, where IPR issues may arise after the joint development of the standard had occurred.

Within standards organisations or alliances, it is often difficult to ensure that partners bring in the most advanced or the state-of-the-art technology and latest information. Patents, copyrights and trade secrets do still exist and not all of the latest or most advanced technologies will be shared amongst partners in alliances. There has to be a balance within each company in protecting its trade secrets and sharing its know-hows in a standard setting scenario. Individual companies will have to decide internally what parts or types of technologies will become part of the discussion within the alliance and what are considered outside this.

The length of time taken for standardisation processes- agreements to be reached and specifications to be agreed upon will take time. There may exist much bureaucracy and other time consuming processes within standards organisations and alliances that would otherwise not surface in a single company standardisation process. The questions as to whether all this impedes the progress of the technology compared to if a proprietary standard was set within a company is something that has to be considered by industry as well.

It may sometimes happen that the same organisation is working on different but somewhat similar standards. It can also be the case that different organisations are working on similar but competing standards. There would probably be some overlap and there are different types of standard bodies or standard setting organisation in the mobile industry. One example is that of the IEEE 802.11 standard or WiFi and the competing ETSI standard HYPERLAN. There were many similarities between the two standards and work from two different organisations in standardisation resulted in competition between the standards. Standards wars do occur when similar competing standards become available and there is only room for one standard.

Other problems associated with standard setting and the different processes and time frames involved can be categorised into two large sections: de Jure standard setting problems and de Facto standard setting problems. Each has their unique advantages and disadvantages but both need to co-exist in technology markets such as the mobile market.

As standardisation of technology continues, it must do so at a pace that matches what the market demand. Today's users have sufficient knowledge of existing technologies to know what they need and what they do not need. In de Jure standard setting, there is sometimes the problem that because it involves a wide spectra of governmental and industrial members working on a particular standard, bureaucratic processes are sometimes difficult to overcome and each process may take longer than necessary to accomplish. However, on the other hand, when all these processes have been taken care of, every detail of the standard may be discussed and discussed fully by the members. When it comes to technologies as those in the mobile sector, every fine detail of the standard should be worked out and agreed upon. Standardisation in the mobile industry is seen as one of the keys to survival- with standardisation, there would be more compatible components and devices available throughout and this would lead to competitive pricing and economies of scale. The lower costs could then be passed on to the users/buyers of the technology or product.

As de Facto standards are ones that are decided by industry rather than by governments, with the market playing a big role, different problems exist. One of which is that the market may be fickle and may pick the technology not by its merits but rather by their whims and fancy. For a company to succeed in a de Facto market, it would probably have to require on factors other than only the technology. To name a few, brand name, reputation and also post sales service may play a part in the decision of the market.

As mentioned earlier, these days, it is quite unlikely that standards are purely de Jure or purely de Facto. In fact, in technology inclined industries such as the mobile industry, it is likely that the standardisation of technology is somewhat mixed: a combination of de Jure and de Facto standard setting such that standards require input from both government authorities as well as alliances and working groups between different firms and companies.

In the mobile industry today, we see government authorities and international organisations work in spectrum allocation activities and in overall co-ordination of resources. This is likely to continue as only on an international and national level can this be controlled. With compatibility and inter- working issues, organisations such as the IEEE are involved in standard setting. These organisations make use of the know-how and capability of members from industry and education in formulating specifications. The importance of input from both sides is ever increasing as the technology and economics are becoming more inter- related. Members of such organisations are sometimes also members of smaller industry standards alliances whose work concentrate on standardisation of parts and interfaces for use industry-wide.

6.8 Standardisation and Potential Disruptive Technologies

Standardisation of technology, both innovative and incremental ones to existing technologies will affect the sustainability and disruptiveness of a technology as it enters he market.

Potential disruptive technologies of the future will no doubt make use of more input from the market. User studies and user needs are being studied all the time. It was not until quite recently companies realise that pure technology cannot carry a product forward. Good business sense as well user requirements are as important as the technology they are trying to put forth.

It would therefore probably be important for SDOs to get the technology standardisation right from the beginning and then to let the market make its decision. Alliances between different industry partners and co-operation in research and development will lead to the scenario where technology and products (including components and other features) are standardised. User studies involving would most certainly help in technology development.

When we look at standards such as GSM and earlier technologies, they were very much based on what the technologists and developers knew and thought users would also want. But of course, one has to consider that at the time of GSM, the general user was not aware of mobile technology as an everyday tool. It was something that was new and required technical expertise in deciding what was best for the user. However, today, mobile technology is so much a part of life that most people own a mobile device. This means that users are very much in tune with mobile technology and also know what they need and do not need in terms of features and applications. The types of features and applications will definitely differ for different segments of the market but this is another discussion. The point made here is that standardisation processes will probably change from one that has been decided by government and industrial organisations to one that depends on market decisions.

The standard setting process of evolved or sustaining technology (as apposed to disruptive technologies) would be easier than new disruptive technologies due to the underlying architecture and technical specifications. Evolved technologies would make use of an earlier version and would be built upon this earlier version while a disruption is likely to include totally new architectures and building blocks. It may therefore be that potential new disruptive technologies would result in more work compared to evolved technologies.

In the past year or two, several potential disruptions have been identified and work on them has been progressing. Although we do not know for sure if these technologies will really have an impact on the industry, we will use them here as examples of how standardisation of such technologies may take place.

WiMAX, as mentioned earlier was defined as the 802.16 standard by the IEEE. Thereafter, the WiMAX Forum was formed to look into standardisation activities of WiMAX. Industry participants mainly made up this forum. Activities centred on having standardised products that are interoperable with one another. WiMAX was originally taken to be a broadband wireless access replacement to wired technologies such as cable and fibre. Its aim was to provide broadband wireless services to regions not covered by wired infrastructure. However, since then a mobile version of WiMAX has been introduced and now a combined fixed and wireless standard has been specified. This means that now WiMAX could, in effect compete against mobile networks such as GSM or UMTS networks. This could prove to be disruptive to mobile operators and also fixed network operators. Whether WiMAX becomes a true standard in the industry will depend, first and foremost on the availability of low cost equipment and also continued industry backing. Today, WiMAX has a lot of industry support and therefore has a bright future, either as a sustaining market change or as a disruption to the mobile market. To be the future industry standard, it must also gain support from users. Users value cost and performance above all else and if WiMAX is able to provide these, then the likelihood of success would be high. With those attributes, it is likely that WiMAX will gain a foothold or at least part of the mobile/wireless market. It however does not mean that it would totally disrupt the earlier technologies. Therefore, standardisation is a process involving many parties ranging from international standards developing organisations to company fora to end users.

Another example is that of Linux. For many years this operating system (OS) has gaining in popularity, especially at the university level and some said that it would be disruptive to the PC market that the Microsoft operating system had dominance in. This, however, has not occurred yet. In a mobile setting, Linux will possibly gain niche markets in firmware OS and content servers. Operating systems on mobile phones are a very important component of the device. Today, the dominant supplier of mobile phone OS is Symbian, which is a consortium led by Nokia and made up of several device manufacturers and other partners. Microsoft is also trying to gain a foothold in the mobile OS business. Linux, an open source software, has been adopted by mobile phone manufacturers such as Motorola. With open source, things are generally dictated by the user licences that come with each source. Standardisation of something Linux would be a very difficult thing to do. Work on open source depends very much on contributors and users[109]. Decision as to whether something should be released into the community is part of the job of the core team. Therefore, it is going to be difficult to standardise open source software as the very nature of open source makes it a de Facto standard and the end users will decide if they want to use it or not.

IP desk top phones have recently entered the market in Denmark. This is seen to be very much a threat to operators as using IP to make phone calls over the internet means bypassing the traditional fixed operator's telephone network and also the mobile operator's network. Applications such as Skype enable users to call their friends who use the same application on their computers. This is also now being available on desktop phones. Soon, it will be available on mobile/wireless phones. BT (British Telecom) is implementing just such a solution named Project Bluephone, making use of their WiFi hotspots located throughout the UK[110]. IP telephony could represent a disruption to conventional telephone network operators and mobile operators. Coupled with the use of cheaper forms of access such as WiFi, a user had WiFi access on his phone and was in a hotspot, he could make use of this Internet connectivity to and the IP phone application to make long distance or international phone calls at a price that the operator cannot offer. The quality of IP telephony has improved immensely over the years and quality of service is now on par with that of conventional telephony. If the number of users grows and the technicalities involved in using IP telephones diminishes, it is a valid possibility that IP phones would disrupt

[109] Some of the information here has been obtained from interviews with Peter Toft, Nokia Corporation, Copenhagen, Denmark and Ari Jaaksi, Nokia Tampere, Finland.
[110] Mark Halper, "VoIP goes Mainstream- You can take it with you", Time Magazine pg55, March 14, 2005.

conventional telephony. Standardisation of IP telephony and its technologies would be very much driven by small companies and perhaps also by large operators. Device manufacturers and equipment manufacturers will also participate. Small consortia or fora will probably be the participants of such technology standardisation processes.

With less de Jure standards entering the market, the user will probably have a bigger part to play in deciding the standards of the future. As the number of technology and applications increase, so do the choices faced by the market and its users. The user is now equipped with more knowledge of technology and products and are able to assert their choices in a market where the number of products is ever increasing[111].

6.9 Case Study- WiFi

WiFi is an interesting wireless technology to study as it provides some insight into technology development and evolution today; addresses the different business available; and is a technology that has gone through a rigorous standardisation processes. WiFi has been used as a case study and this case study examines the market developments relating to WiFi. As this is a technology which has already been on the market now for some time, compared to other wireless technologies, we are able to make use of available data and information to base our case on. We can explore the extent to which this technology has already changed the rules of the game in the mobile and fixed network access markets. It will also give an indication, how companies have today will react to the emergence of new wireless and mobile technological possibilities.

6.9.1 Technology

WiFi or the IEEE 802.11 standard makes use of both the licensed and unlicensed spectrum for local area wireless networking. The 802.11b is still the earliest and the most popular of the different WiFi standards. Theoretically, it would allow for transmission rates of up to 11Mbps. The newer 802.11g standard, which allows for transmission of up to 54Mbps, is gaining in popularity and is fully backward compatible with the earlier 802.11b version and is being adopted by laptop manufacturers, as was done earlier with the 802.11b standard. These two operate in the 2.4GHz frequency spectrum. The 802.11a standard gives up to 54Mbps at 5GHz. Earlier versions of this standard were prone to security breeches and network security was an issue that was not originally addressed in detail. Most users make use of WiFi with laptop computers. However, as more and more mobile devices such as phones and PDAs become more

[111] The author acknowledges that not everyone will agree with this point but it is generally regarded as a growing trend that users are becoming more knowledgeable regarding technologies and products.

popular, there would be a need to further extend the possibilities of WiFi to include much more. This has led to additional work being done on the 802.11 standard. Now, with the 802.11n, 802.11s and 802.11r, features such as higher throughputs, fast roaming and meshed networking are being carefully implemented. It is hoped that with these new features, that WiFi will be able to provide and WiFi. However, rectification of the standard has led to much greater development.

Further development of the 802.11 standard will result in probably competition to other wireless standards such has the IEEE 802.16 and also mobile standards. The key disadvantage about the original WiFi standard is that it is immobile- that is it is a wireless technology but it does not have the freedom of movement. This has meant that it is not able to compete in the mobile technology market. One application that is of great interest to supporters of WiFi is that of VoIP over WiFi. With the increasing popularity of VoIP, many see WiFi as one of the possible means of using VoIP with some form of mobility. This is where the earlier mentioned 802.11n, 802.11s and 802.11r standards would come into use. The 802.11r was established to ensure ease of use of wireless VoIP and other real time applications. The 802.11s for meshed WiFi networks will extend the coverage of WLAN networks. It does this by interconnecting nodes to allow data to be relayed from one node to the next and, by doing so, extending the coverage of a WiFi network. These two standards are extensions of the earlier 802.11x standards. When these two standards come into implementation, it would provide a means for applications such as VoIP over WiFi to grow and these could potentially pose as a substitute technology to that of mobile technologies. With these developments, there is the further likelihood that new operators operating fully meshed WiFi networks would appear in the market and possibly compete against the mobile operators of today.

6.9.2 Market and Business

Businesses soon adopted WiFi internally and operators started to see the advantages of deploying cost-effective WiFi hotspots in popular areas such as airports and cafes. This led to many hotspots mushrooming across many countries.

WiFi could have been adopted by companies in their business strategies as being complementary products to their current offering or as substitutes that could in effect destroy their present services. Whichever way mobile operators reacted to WiFi is an indication of the direction that they would take with future wireless technologies.

The technological developments being undertaken today for the next generation of WiFi will see to the possibility of extending WiFi into a mobility context or one that extends coverage over a greater area.

Today we see different countries deploying WiFi hotzones. Hotzones are neighbourhood wide or downtown area wide wireless. Several cities have created wireless hotzones, including (Radionet):

- Finland: Vantaa, Vaasa, Mäntsälä
- Australia: Adelaide
- New Zealand: Wellington
- Germany: Hamburg, Bochum
- Netherlands: Eindhoven
- Portugal: Lisbon
- U.S: Long Beach, San Francisco, Portland, Baltimore, Pittsburgh, Boston, New York City, San Jose

6.9.3 How WiFi is Faring Globally

WiFi has been around for several years now and hotspots are still mushrooming around the world. The deployment of WiFi is simple and low cost for operators, and these are seen as important advantages of WiFi as compared to UMTS. However, contrary to the low costs of equipment and setup, prices to users are still far beyond costs. Equipment such as the access points and data cards are readily available and it is not difficult to backhaul access points via DSL or fibre (and maybe WiMAX in the future) to an ISP. The fact that WiFi makes use of unlicensed spectrum makes it attractive to deploy. WiFi may be deployed by virtually anyone. WiFi providers range from incumbent operators to smaller firms or co-operatives that have set up WiFi networks for the convenience of their customers and clients or as a means of luring in customers to their core business (e.g. cafes with WiFi access). The market development of WiFi on a global scale is not uniform and the following subsections will give an idea about the different global market segments: Europe, Asia and the USA.

Europe

If one talks about GSM technology, then Europe is the most saturated regional market. However, operators in some European countries have had to pay the highest licence fees for 3G licenses and that, coupled with high infrastructure costs of UMTS, have propelled some operators to look to other alternative streams of revenue. WiFi presents an alternative and the low costs of equipment and ease of deployment are a welcome change to what is experienced with UMTS. Table 11 shows the number of WiFi in Europe.

Table 11 shows that the United Kingdom and Germany have deployed the largest number of hotspots. In the United Kingdom, from April 2005 to January 2006, the number of hotspots has increased from 1985 to 12398. Incidentally, mobile operators in these two countries also paid the most in 3G licence fees. In Europe, operators in some countries have aggressively adopted and deployed WiFi either as stand-alone systems or as part of a larger service offering. Many of these operators are in fact the incumbent operators of either fixed or mobile networks or both. For example, in the United Kingdom, WiFi provider, BT Openzone has around 2592 hotspots[112] and in Germany, T-Mobile and T-Com have 6420 hotspots[113] across the country. These operators are the former telecommunication incumbents in their respective countries and have now opted to deploy numerous hotspots. T-Mobile has not limited its operations to Europe; the company also has a large number of hotspots in the USA and across Europe.

Country	Number of WiFi Hotspots (April 2005)	Number of WiFi Hotspots (Janurary 2006)
Austria	675	802
Belgium	131	849
Cyprus	2	4*
Czech Republic	151	217
Denmark	571	918
Estonia	22	22*
Finland	10	370
France	827	3831
Germany	5618	8343
Greece	14	78
Hungary	61	76
Iceland	41	42*
Ireland	72	259
Italy	300	1715
Latvia	53	204
Liechtenstein	5	7*
Lithuania	12	18
Luxembourg	4	6
Malta	22	35
Netherlands	488	1398
Norway	117	344
Poland	103	119
Portugal	92	503
Slovakia	23	32*
Slovenia	50	56
Spain	373	1177
Sweden	87	651
Switzerland	1148	2134*
United Kingdom	1985	12398

Table 11. Number of hotspots in European nations[114] [115]

[112] http://www.jiwire.com/hotspot-hot-spot-directory-browse-by-country.htm?provider_id=477 – cited 150106
[113] http://www.jiwire.com/hotspot-hot-spot-directory-browse-by-country.htm?provider_id=420 – cited 150106
* Information marked with an * were obtained and compiled from http://www.hotspot-locations.com/ . These numbers represent only hotspots that have been registered with these websites. – cited 070405 and 150106

Asia

Asian countries such as Japan and South Korea have in the past years been at the forefront of mobile technology. Japan became the first country to introduce 3G in 2001 and South Korea followed suit soon after. The Japanese and South Korean markets are known to be the most developed in terms of wireless products and services. WiFi and WiFi products are catching up in popularity in both countries. Japan as well as South Korea has extremely high Internet penetration levels, largely due to the wireless data mobile services available to mobile phones by means of 3G technology. Fibre and DSL technology are also very well developed, especially in South Korea as cities are very densely populated.

In Japan, the largest provider of WiFi hotspots is NTT Com. Other countries in Asia have begun to catch up in terms of WiFi hotspot deployment. The table below, Table 12, shows the number of hotspot in selected Asian countries. In South Korea was reported to have some 12000 hotspots in place in 2004[116] and was planning to increase to over 20000. As much of the population are in built up areas and have already had experience with high speed mobile data services, the use of WiFi is seen to supplement this.

Country	Number of WiFi Hotspots (April 2005)	Number of WiFi Hotspots (Janurary 2006)
China	23	494
Hong Kong	272	720
India	118	384
Indonesia	57	63*
Japan	781	3625
Malaysia	433	464
Singapore	501	682
South Korea	> 12000	> 14000
Taiwan	110	650
Thailand	52	176

Table 12. Number of WiFi hotspots in selected Asian countries[117]

[114] The information in the second column of this table were obtained and compiled from http://www.hotspot-locations.com/. These numbers represent only hotspots that have been registered with these websites. – cited 070405 and 150106

[115] The information in the third column of this table were obtained and compiled from http://www.jiwire.com/hotspot-hot-spot-directory-browse-by-country.htm?country_id=209. These numbers represent only hotspots that have been registered with these websites - cited 070405 and 150106

[116] http://www.techdirt.com/news/wireless/article/4010 - cited 070405

[117] The figures in the second column were obtained and compiled from http://www.hotspot-locations.com/, with the exception of South Korea, which was obtained from http://news.com.com/Korean%20firm%20KT%20shoots%20for%20world's%20largest%20Wi-Fi%20network/2100-7351_3-5217060.html. The figures in the third column were obtained and compiled

North America

The United States has one of the largest bases of WiFi hotspots in the world. The adoption rate of WiFi has been great in the United States and this technology is proving to be very popular amongst US enterprises and it was reported that around 700000 enterprises make use of WiFi technology[118]. The United States is traditionally the home of the Internet and the people here have a strong Internet culture and it is not surprising that the number of WiFi hotspots number so highly, as this is seen as an extension of the Internet.

Country	Number of WiFi Hotspots (April 2005)	Number of WiFi Hotspots (Janurary 2006)
Canada	553	1374
USA	9274	35681

Table 13. Number of WiFi hotspots in Canada and the USA[119]

Table 13 shows the number of hotspots in the USA and Canada. A couple of reasons why WiFi seems to be so popular in the United States is probably the low costs of infrastructure and setup for operators and also the fact that the unlicensed spectrum is used, dispelling the need to obtain expensive operating licences. However, the single service offering of only WiFi has proven not to be a viable business plan and has been taken over by larger operators who offer WiFi as a part of their larger suite of mobile, wireless and fixed services.

Developing Nations

The developing nations of the world are far behind the developed ones in terms of communication infrastructure. Wired infrastructure to homes is costly and one of the ways of giving access to the people of these nations is through WiFi. Schools and other government institutions such as libraries may be used to provide connectivity to the Internet. The fact that developing nations are the poorest amongst the world has made governments here very careful in licensing schemes. Free unlicensed frequency spectrum is often not made available as the potential for governments to make some revenue from licensing spectrum in the future remains. Governments in these countries are therefore slow to uptake on WiFi and other technologies. In reality, the costs of user equipment to most of the population in developing nations are still

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from http://www.jiwire.com/hotspot-hot-spot-directory-browse-by-country.htm?country_id=209, with the exception of Indonesia, which was obtained from http://www.hotspot-locations.com/ and South Korea, which was obtained from http://wifinetnews.com/archives/005570.html These numbers represent only hotspots that have been registered with these websites. – cited 070405 and 150106

[118] http://www.infoworld.com/articles/hn/xml/02/08/01/020801hnwlangrowth.html?s=rss&t=wireless&slot=5 – cited 070405

[119] The figures in the second column were obtained from http://www.hotspot-locations.com/ and the figures from the third column were obtained from and compiled from http://www.jiwire.com/hotspot-hot-spot-directory-browse-by-country.htm?country_id=209

considered high does not represent a large enough market to any potential operator. However, compared to the infrastructural costs of wired technologies, it may be that wireless technologies like WiFi be deployed more significantly in the future. The attraction of the Internet and all that it offers will perhaps be the push to deploy WiFi in developing countries.

6.9.4 WiFi- From Technology to Market

WiFi has been deployed globally by numerous different operators in the last few of years. Operators such as T-Mobile and SwissCom have rigorously deployed WiFi networks. T-Mobile has roaming contracts in place with WiFi operators around the world. Therefore, we see that mobile operators are also making use of the popularity of WiFi to increase their revenue. We can also see that WiFi addresses a different market to that of UMTS. Users may overlap, but the target use of WiFi is different to that of mobile networks such as UMTS. From an abstract point of view, this could lead to the conclusion that WiFi is a disruptive technology. However, the conclusion could also be that the different technologies such as UMTS and WiFi complement one another. Only a market analysis can provide that kind of conclusion.

T-Mobile International is a wholly-owned subsidiary of Deutsche Telekom. Currently, there are four groups within Deutsche Telekom, one of which is T-Mobile. T-Mobile offers not only mobile services to their customers but also WiFi access. In Germany, T-Mobile and T-Com, another of Deutsche Telekom's group, has deployed around 6420 hotspots[120]. What is interesting about T-Mobile is that it is originally a mobile operator that now provides WiFi access as well. WiFi was initially thought of as being a disruption to mobile operators. But we see here that a traditional mobile operator has taken WiFi under its operations and deployed one of the largest bases of hotspots worldwide. They not only provide hotspots in Germany but also in other European countries and in the United States. T-Mobile has in fact taken a possible substitute product and made it a part of their business strategy. By making WiFi a part of their bigger operation, T-Mobile is able to position itself as an operator that addresses the different requirements of different types of users. It also allows T-Mobile to offer bundling of services that include both mobile and WiFi access.

Another example is TDC, the Danish Incumbent operator. TDC has its own GSM network and also possesses a UMTS license. This means it will have to deploy a UMTS network, in accordance with license agreements. However, in the last year, TDC has also aggressively rolled out WiFi hotspots all over Denmark. TDC Denmark

[120] http://www.jiwire.com/hotspot-hot-spot-directory-browse-by-country.htm?provider_id=420 – cited 150106

has rolled out 595 hotspots[121] in places such as airports and petrol stations and is the largest WiFi operator in the country.

Now, this is in direct contrast to Christensen's words that companies would choose either to locate the department dealing with the potential disruptive technology in a separate location to the headquarters. Either one of these methods would ensure that the culture and existing process of the firm do not hold back the progress of the potential disruptive technology that the separate entity would develop its competencies for the disruptive technology outside the control of the parent company. However, given the examples above with T-Mobile and TDC Denmark, we see that instead of adopting WiFi as a threat, they have adopted WiFi as a complementary product. Mobile companies are seen to have reacted differently to WiFi than originally predicted by incorporating WiFi technology into their suite of services. These companies have chosen to incorporate WiFi to their current service portfolio rather than set up separate companies or departments.

As mentioned in Chapter 2, one of the reasons for doing this would be to save on resources and to better manage the use existing resources, such as skilled manpower, planning activities and other logistical assets. Furthermore, by having the new department close at hand, there is the possibility of the different departments working together in the creation of attractive co-marketing strategies and to offer bundled services. These two companies have identified WiFi as a complementary product rather than a substitute to existing products and in so doing, were able to incorporate WiFi into the business strategies of their company as a whole. As a complement, it was then introduced to the market as a supplement to their mobile network. WiFi was adopted as a sustaining technology that could complement their mobile technology network and was not viewed as a threat or as a substitute to their mobile network. For these formed incumbents, if WiFi services had been introduced through a separate company or group, it would not be able to make as good use of the synergies that already exist within the existing company. By taking the stance that WiFi is not a disruption, it was able to successfully incorporate WiFi operations into the existing company.

6.9.5 Standard

The standardisation process of WiFi began back in 1990, but it had been in existence since 1985[122]. WiFi came about when the Federal Communications Commission (FCC)

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[121] http://www.jiwire.com/hotspot-hot-spot-directory-browse-by-country.htm?provider_id=1000148 – cited 150106

[122] http://intel.com/standards/case/case_802_11.htm - cited 160106

decided to open several bands of wireless spectrum, licence free[123]. These bands was a so called “garbage bands” or “junk bands” because different devices from microwave ovens to medical devices made use of these bands.

In 1990, an IEEE committee was charged with looking at the 802.11 standard. In 1992, the IEEE 802.11 project committee formally established the functional requirements for a wireless LAN protocol[124]. In 1997, the IEEE 802.11 standard was ratified. This committee had to establish a universal standard for the wireless market[125]. In 1999, the IEEE ratified and approved the 802.11b standard[126]. The 802.11b operates in the Industry, Medical and Scientific (ISM) band of 2.4GHz[127]. It would retain the error-correction, security, and power management of the original 802.11 standard[128]. The other standard to be ratified was the 802.11a standard which operates in the 5.3GHz and 5.8GHz Unlicensed National Information Infrastructure bands[129]. Later, the 802.11g standard was approved. It is backward compatible with the 802.11b standard and like the 802.11b, makes use of OFDM and achieves speeds of up to 54Mbps. The continual development of the 802.11 standard with the 802.11r, 802.11s, and 802.11n show the potential that still exists with this standard. Table 14 is an extension of Table 10 and summarises the 802.11 standards development throughout the years.

The success of the 802.11 standard so far has been quite surprising and has caused mobile operators and others alike to re-assess their strategy concerning this particular technology. As the standard continues to develop, both mobile operators, WiFi operators and others will have to adapt to its development.

As can be seen from Table 14, newer 802.11 standards have been specified after the original ones. This has been done to address weaknesses of the earlier standards and to develop the 802.11 standard for the new mobile and wireless market. A lot of research and development into newer technologies such as MIMO techniques have happened in the past few years and these developments are now being used by the 802.11 committee for the newer, evolved WiFi standard. As far as standardisation is concerned, the 802.11 has had an interesting past and will have an interesting future.

[123] http://intel.com/standards/case/case_802_11.htm - cited 160106
[124] http://intel.com/standards/case/case_802_11.htm - cited 160106
[125] http://www.byte.com/art/9405/sec7/art3.htm - cited 160106
[126] http://www.networkworld.com/news/tech/0214tech.html - cited 160106
[127] http://intel.com/standards/case/case_802_11.htm - cited 160106
[128] http://www.networkworld.com/news/tech/0214tech.html - cited 160106
[129] http://www.networkworld.com/news/tech/0214tech.html - cited 160106

IEEE 802.11	The original 1 Mbit/s and 2 Mbit/s, 2.4 GHz RF and IR standard
IEEE 802.11a	54 Mbit/s, 5 GHz standard
IEEE 802.11b	Enhancements to 802.11 to support 5.5 and 11 Mbit/s
IEEE 802.11c	Bridge operation procedures; included in the IEEE 802.1D standard
IEEE 802.11d	International (country-to-country) roaming extensions
IEEE 802.11e	Enhancements: QoS, including packet bursting
IEEE 802.11f	Multi-Access Point Protocol
IEEE 802.11g	54 Mbit/s, 2.4 GHz standard (backwards compatible with 802.11b)
IEEE 802.11h	Spectrum Managed 802.11a (5 GHz) for European compatibility
IEEE 802.11i	Enhanced security
IEEE 802.11j	Extensions for Japan
IEEE 802.11k	Radio resource measurement enhancements
IEEE 802.11m	Maintenance of the standard; odds and ends.
IEEE 802.11n	Higher throughput improvements
IEEE 802.11p	WAVE - Wireless Access for the Vehicular Environment
IEEE 802.11r	Fast roaming
IEEE 802.11s	ESS Mesh Networking
IEEE 802.11t	Wireless Performance Prediction (WPP) - test methods and metrics
IEEE 802.11u	Interworking with non-802 networks
IEEE 802.11v	Wireless network management
IEEE 802.11w	Protected Management Frames

Table 14. Development of the 802.11 standard and their characteristics[130]
Source: (Intel), (IEEE 802.11 WG May. 2004), (IEEE 802.11 WG Aug. 2004a), (IEEE 802.11 WG Aug. 2004b), (IEEE 802.11 WG May. 2005).

6.9.6 Conclusion

As the WiFi has not fully developed its potential in the market, definitive conclusive remarks will not be possible and further study to follow up on its development will have to be done in this area. In particular, work should be done to look closely at the development of WiFi with respect to the 802.11r and 802.11s standards as these potentially could result in new operators competing for a share of the mobile operators' markets. Also, the development of WiMAX will have to be closely watched to determine its full impact on the mobile industry and whether it will indeed be a disruption to mobile technology. Whether WiFi or other new wireless technologies will be disruptive to the mobile industry remains to be seen and as discussed; and will very much depend on the corporate strategies of companies involved, such as mobile operators and handset manufacturers.

[130] Source: http://en.wikipedia.org/wiki/IEEE_802.11 and http://standards.ieee.org/getieee802/ cited 200106

6.10 Discussion

Together with Chapters 4 and 5, this chapter has shown that different aspects of a technology are equally important qualities that see to the success or failure of that technology or product. Technological considerations, business considerations as well as standardisation play important roles in the development and the dissemination of a new technology. The evolution of technologies is a culmination of several things which have been discussed in some detail in this chapter.

Technologies that are potentially disruptive to the market are also ones that need to go through the different standardisation processes. What separates a disruptive technology from a sustaining one probably linked to the different combinations of technical considerations, business know-how and standardisation practices. Evolution takes place on many different planes and all these will result in a technology or a product that could revolutionise the industry.

As shown in Figure 27 below, technology evolution can take place only when the technical, business and other considerations are taken into account. These different segments are part of the requirements of a new technology. Only when we have all these can evolutionary process take place and the emergence of new mobile and wireless technologies appear. Firstly, the technical considerations which are considered the basis of the technology evolution have to be developed. Without new or improved technology, evolution of the current would not take place. The second point to consider is that of the business or market. These are important factors as well in the evolution of technology as without a business model potential market, the evolved technology would not succeed. It is important to consider the effects and the potential gain in the introduction of a new technology to the market. The last point is that of standardisation. In today's mobile industry, standardisation work takes place on many planes and are important

Evolution of technology or the revolution of technology may or may not result in disruptive technologies. As discussed in Chapter 2, individual firms involved in development of technologies will first have to decide if a certain technology meets their strategic plans and whether they should be developed as complements or regarded as substitutes to their product. By choosing to develop a technology as a complement means that it would likely turn out to be a sustaining technological change to the original technology or product. By regarding the new technology as one that is going to compete against their original product will likely result in that new technology becoming a disruptive technological change to their original product when this technology develops enough to enter the main market place.

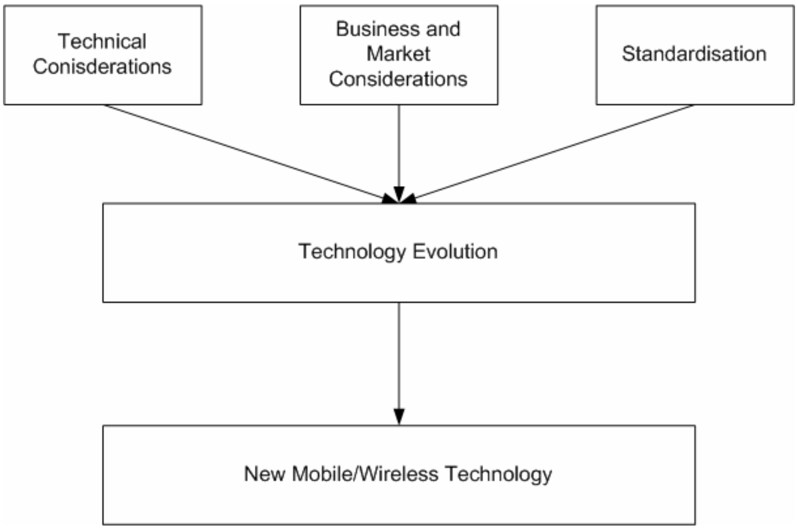

Figure 27. Requirements in technology evolution.

Standardisation process and standards organisations have played a big part in determining the direction of mobile telecommunication from its conception to what it is today. As standardisation organisations evolve and different industrial alliances are formed in the name of standardisation, we may see two very different scenarios emerging: the first is one where alliances and SDOs work on technologies and innovation flows from these organisations; the second is that there will be more protectionist when it comes to their technologies and sharing of information and technology know-how amongst alliance partners will limit innovation. Just how much proprietary information a company will share with others will determine technology development. There will have to be a balance between the amount and type of technological information shared and what is kept as trade secrets or proprietary information.

Both De Jure and De Facto standards will likely continue to exist in the mobile and wireless market. The degree of penetration of each of the standard types will be determined by the market and the type of market the technology exists in, e.g. USA versus Europe. Standardisation of technology by large international organisations is needed because they have the influence over the entire industry and work is done on an international basis. Smaller industry led alliances will also be a part of the future market as there is a need for companies to work together for reasons such as setting standards for components and interfaces. Figure 28 summarises the different standards policies, and characteristics. The evolution of technology has certainly led to some changes in the way standardisation occurs within the mobile and wireless industry and the processes and types of standards development organisations will not stagnate. It will likely continue to change and evolve to meet the needs as technology and business of the industry changes.

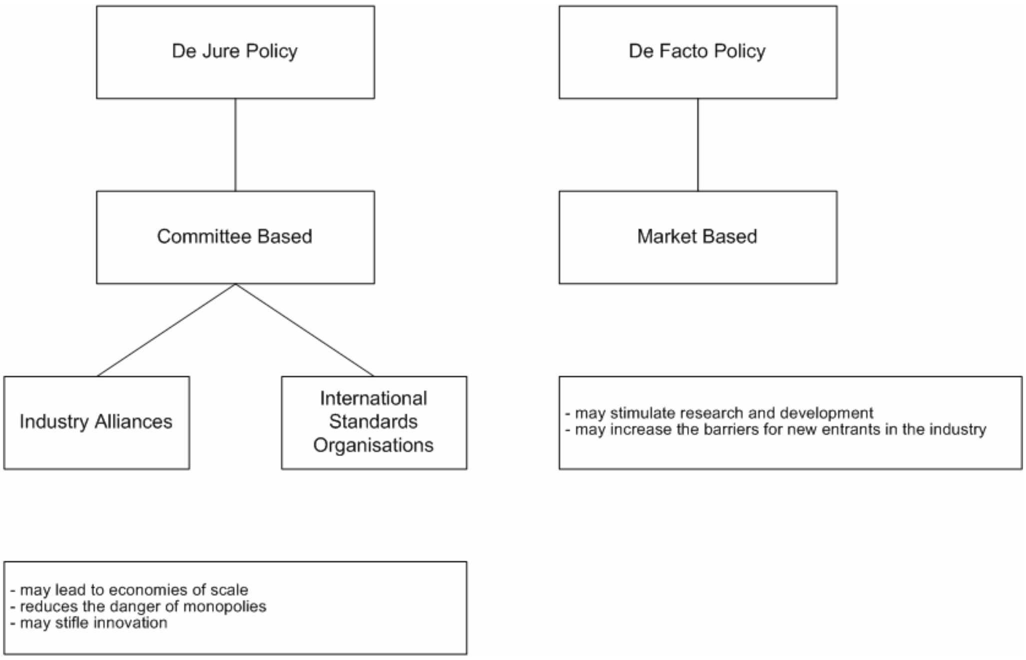

Figure 28. Different standards policies and their characteristics.

Standardisation is needed to oversee interoperability and also conformity of technologies. But in this way, standardisation will also lead to the stifling of innovation. The nature of formal standards organisation will perhaps lead to an industry which is not as innovative as it could be with proprietary technologies.

The ITU has confirmed its stance in that standardisation will look to the complementarity of new technologies with old. With this stance adopted by formal standards organisations, it could mean that potentially disruptive technologies may be adopted as complements rather than as substitutes. As radical technologies may be adopted as either complements or substitutes, it is likely that with standardisation, that the former will be selected. Standards organisations are expected to look to complement old technologies with new ones but not to substitute old technologies with old ones. Continuity in technology evolution will probably be chosen over interruptions.

7 Business Models

There are many different definitions of what a business model is. Work on business models and its concepts have become a rather popular endeavour amongst business strategists and economics researchers. Several different opinions will be looked at and our definition as to what is a business model and what it contains will also be explained here.

In academic literature the term business models has not really been used until the emergence of the Internet and since then this term has been used in the analyses of most technology related businesses e.g. the mobile business. Most academic publications have used the terms strategy or corporate strategy prior to this. It is therefore relevant to first include some historical aspects from strategy in a literature review of business models.

Business models are growing in importance in today's mobile and wireless industry. As technology changes affect the industry, so does the business change. Part of this change includes the business models and business strategies that companies will take with new technologies. When we talk about a heterogeneous network, we refer to one where ubiquitous access and seamless roaming in a personalised environment is the vision of the future of communication. This concept has been part of the MAGNET project vision. MAGNET is an integrated project supported within the Sixth Framework Programme of the EU Commission. The project acronym stands for "My personal Adaptive Global NET"[131].

MAGNET sees the importance of user requirements and personalisation in order to develop technologies and services that can be used simply in everyday situations. The result will be one of a heterogeneous network with different types of access types allowing the user to get the services wanted at anytime and in any place. The idea of a PN (Personal Network) is introduced. A PN is a collection of interconnecting PANs (Personal Area Networks). Interconnectivity is done through wireless and mobile access. The PN is the entire network of an individual and is not restricted to the locality of the user. The concept of the Personal Network is shown in Figure 29.

PNs represent one of the paths that mobile and wireless technology could move to in the future. New business models will be needed in the new PN market. This is an area which has not been explored before and represents uncharted technological and business challenges. From this project, it was quite clear that two most important

[131] http://www.ist-magnet.org/index.html - cited 050106

players in the PN environment were the mobile operator and the device manufacturer. This chapter has been written with contribution and advice from Rune Roswall from TeliaSonera, Sweden. It develops business models from the point of view of these two players and gives an insight into the future of the mobile and wireless business by analysing the changing business model.

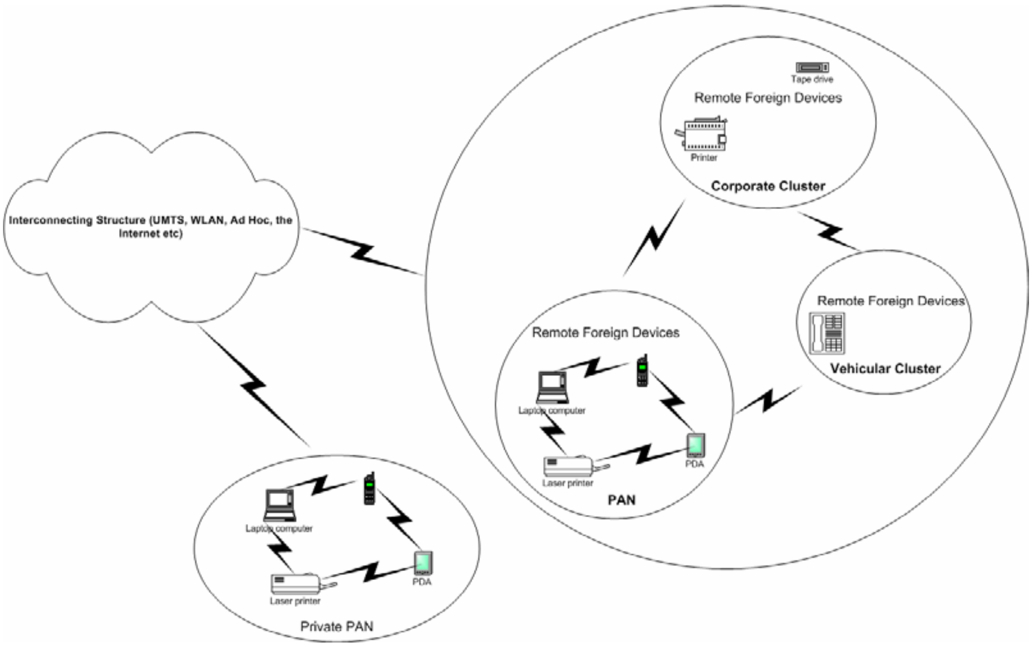

Figure 29. The PN Concept

7.1 History of Business Model Definitions

Alfred Chandler presented in 'Strategy and Structure' from 1962 a systematic and comparative account of growth and change in the modern industrial corporation. In this work he analyzed how enterprises should react according to different challenges caused by changes outside or within the company (Chesbrough and Rosenbloom 2002).

Igor Ansoff found Chandler's ideas interesting and applied further aspects to the concept of corporate strategy in his book 'Corporate Strategy' from 1965. In this book Ansoff created a framework where firms could adjust their strategy according to the opportunities and threats that the environment poses on them. In this context environment refers to factors as competition on the market, macro economic conditions, government policies, regulations, natural environment, national boundaries, and technological change (Afuah and Tucci 2001).

A number of other writers in the management literature contributed to developing the concept of corporate strategy, among these can be mentioned, B. S. Silverman & H. Mintzberg. Later on C. K. Prahalad and R. A. Bettis (Prahalad and Bettis 1986) incorporated a set of heuristic rules, norms and beliefs into the management literature, so that corporate managers could use these as guidelines when making decisions for a corporation or business (Afuah and Tucci 2001).

K. Andrews in his book “The Concept of Corporate Strategy” from 1971 made the distinction between business strategy and corporate strategy. Where business strategy is the product market choice made by a division of a diversified company, a corporate strategy is a superset of business strategies (Afuah and Tucci 2001).

The concept of business models builds upon experience from earlier works on corporate strategy or business strategy and is, therefore, not a unique concept on its own. Business models as a concept was introduced with the emergence of the Internet. Paul Timmers’ article ‘Business models for E-commerce’ from 1998 is one of the first works on business models (TImmers 1998). In this article he outlined the characteristics of business carried out through the Internet. Later on the concept of business model was expanded to other sectors and economic situations.

The first specific works on business models such as Timmers (Timmers 1998), Rappa (Rappa 2001) and Kaplan & Sawhney (Kaplan and Sawhney 1999) focused on studies of taxonomies, i.e. categorizing business models into different groups.

Later work by Afuah and Tucci (Afuah and Tucci 2001) and Chesbrough and Rosenbloom (Chesbrough and Rosenbloom 2002) were focused at splitting up business models into their fundamental atomic elements.

Industry specific business models have also been studied such as those by Krueger, van der Beek and Swatman. (Krueger et al 2004), Rappa (Rappa 2004), Shubar and Lechner (Schubar and Lechner 2004) and Yousept and Li (Yousept and Li 2004).

Reference models by Hamel (Hamel 2000) and Linder and Cantrell (Linder and Cantrell 2000) as well as meta models or ontologies by Gordijn (Gordijn 2002) and Osterwalder (Osterwalder 2004) and Faber et al (Faber et al 2003) are also part of business model studies that have been done in recent years.

Since literature on ‘business models’ are built upon earlier works in the management literature it is relevant to focus on these works for understanding the concept of business models. Michael E Porter’s classic books ‘Competitive Strategy’ from 1980 and ‘The Competitive Advantage of Nations’ from 1990 have especially inspired modern books on business models (Porter 1980) (Porter 1990). Porter himself has criticized the concept of business models as being unclear and taking the focus away from business strategies, which is central for businesses position in the market (Porter 2001).

The concept of business model has furthermore been criticized by Hawkins for not adding anything new to studies of business interactions, since it builds on an already existing planning models, financial models, revenue models, and organizational models (Hawkins 2002).

Hawkins (2002), on the other hand, found that the strength of the business model concept is that it considers how new technologies are taken into market. This can be illustrated by a recent publication by Henry Chesbrough ‘Open Innovation – The New Imperative for creating and profiting from Technology’ (Chesbrough 2003). In this book he analyzes in detail how a business can profit from innovation as well as discusses how business models must be modified according to the nature of the innovation. The central aspect of business models in relation to technological development is thus that the business model has to be modified to fit the specific technology. Moreover, it is important that new business models are formed and integrated in the existing model (Prasad 2004).

Business models change across industries and technologies. The literature on business models is for that reason often applied to a specific technology or industry. As an example of this type of literature, as mentioned earlier, is that of Allen Afuah and Christopher L. Tucci’s book from 2003 ‘Internet Business Models and Strategies’ (Afuah and Tucci 2003). This specific book is about how to make money out of the Internet, but it uses definitions and terms from Andrew’s book from 1971 mentioned above (Chesbrough and Rosenbloom 2002). Other reflections of customized business models per innovation can be observed in Prasad’s article, ‘Wireless Local Area Network: A case of information cascade’ (Prasad 2004).

As we can tell from the magnitude of different areas of research in business models, the term “Business Models” is probably one of the most used terms in business theory today. However, no one clear definition of a business model can be found and several similar and related definitions have come to light over the years.

As written by Slywotzky, a business model may also be defined as "the totality of how a company selects its customers, defines the tasks it will perform itself and those it will outsource, configures its resources, goes to market, creates utility for customers and captures profit" (Slywotzky 1996).

According to Petrovic, the business model describes the logic of a "business system" for creating value that lies behind the actual processes (Petrovic et al 2001).

Another popular definition of a business model is that it provides a description of the roles and relationships of a company, its customer, partners and suppliers, as well as the flows of goods, information and money between these parties and the main benefits for those involved, in particular, but not exclusively the customer (Bouwman 2002).

Faber et. al. described a business model as a network of companies intending to create and capture value from the employment of technological opportunities. Different technical, user, organizational and financial requirements have to be accommodated and balanced (Faber et al 2003).

The last definition of a business model will be used as a basis for our analysis of business modelling within the mobile industry. Osterwalder's (Osterwalder 2004) business model ontology has great similarities to that of Faber's (Faber et al 2003) business model description. The Faber et al business model design is an expression of the Osterwalder model and others and will therefore be used in the analysis in this chapter. Other definitions will be accounted for within the analysis. The discussions in this chapter will consist of what a business model actually is and what it consists of. It will also look at how different actors of the value network will obtain revenue as part of their activities.

7.2 What is a Business Model?

Essentially, a business model is developed to meet the demands of various forms of customers, namely, enterprise customers and/or consumers (non-enterprise customers). Furthermore, a business model situates the company in relation to other companies in the value chain/network. And moreover, it deals with the distribution of revenue among the companies in the value chain/network. Depending on the target, the model varies. This is due to the factors, which influence it.

We also note that there has to be a feedback loop between the internal value chain and the external value chain. Both chains need to be aligned. Internal activities of an organization should be aware of external factors, since they determine the demand for a product and service and also other influences, such as regulations, competition, standardization, substitutes and buyers' and sellers' power. Most of the factors are constantly changing the environment in a haphazard movement. The changing environment requires a business model, which constantly adapts to change. Hence, a business model can go through an evolution or a revolution. Hamel in his business models framework combined the internal and external analysis of the firm's value creation process (Hamel 2000). It also included the innovation aspect of the strategy formulation.

Sustaining changes, in the perspective of product launch means that the business model naturally changes as a new incrementally innovated product is launched. Disruptive changes means that the product being launched is a radical innovation and hence requires a fundamental re-formulation of the paradigm. An example of this would be the Internet, where e-business has fundamentally changed the way companies conduct their business transactions.

Since a business model is a conduit that transfers value of innovation to the users, managers of the innovation must have knowledge on the innovation's character as well as on the market where the new product must be implemented.

7.3 Business Model Concept

The business model concept is able to describe the inter-relationships between different entities of the value network and their processes that take place between each of them. Following the design model put forth by Faber et al, the business model will be used to analyse not only the service aspect but also the organizational, technology and financial aspects. According to Faber et al. (Faber et al 2003), there four interrelated design domains, which is shown in figure 30. It shows the interrelated design domains of a business model. Each of these will have to be looked at individually in order to design the best business model for each of the companies in the value network.

Because the finance domain is somewhat related to the charging model of a PN, it is possible to make use of the finance design of the business model to analyse and describe how the PN charging model will look like.

The four domains are interrelated domains. Briefly, the four domains are described here:

Service Design: Description of the service (value service), which this network of companies will offer to a target group of users.

Organisation Design: Description of the network of different actors that is required to deliver the value services to the end users. Also the roles played by each actor in the network.

Technology Design: Description of the fundamental organisation the technical system and technical architecture that is needed to deliver the value service.

Finance Design: Description of revenue that is intended to be obtained or earned from the value service - Includes risks, investments and revenue division amongst the different actors.

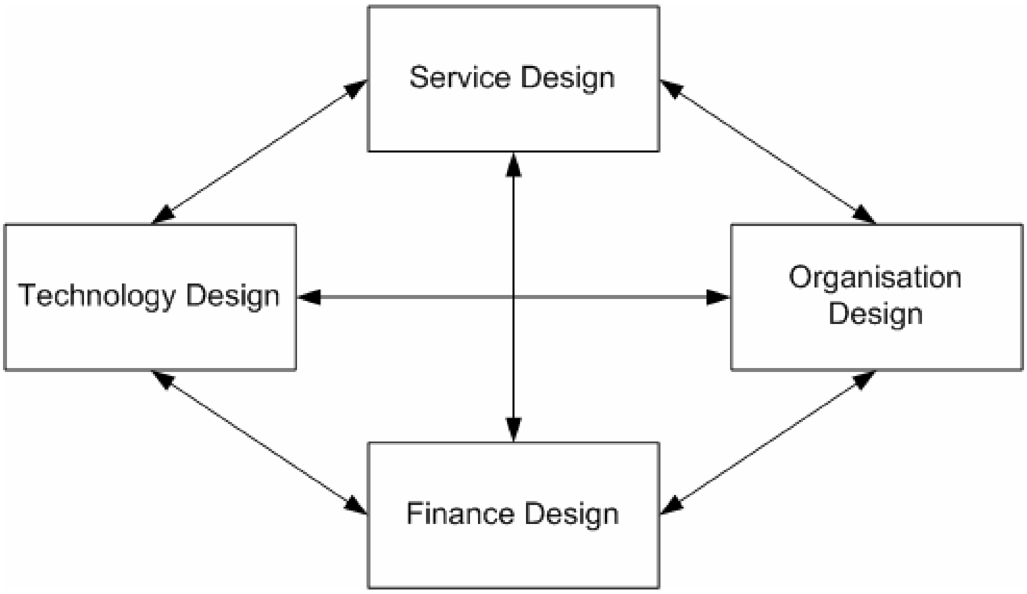

Figure 30. The four inter-related design domains
Source: (Faber et al 2003)

7.3.1 Service Design

The main objective of the service design is to present 'value' to the end user. The provider intends and delivers a certain value proposition while the end user expects and perceives a value proposition. One other important issue on service design is the nature of the service or innovation. This can be categorised into two types: the first is a new version service, which is an evolution of an existing service to make it better, and the second is an entirely new service, a revolutionary service that is new in all aspects (Faber et al).

The concept of value is also important. Value is the worth in usefulness or importance that is placed on a certain product or service. In the service design, four different types of values are studied. Differences exist between the intended value, the delivered value, the expected value that the end user expects from the product or service and the perceived value.

7.3.2 Organisation Design

The organisation design, as mentioned earlier, is a description of the value network that is needed to realise a particular service offering (Faber et al). This network may consist of many different actors that have certain resources and capabilities, that when brought together, will create value for the customers and at the same time, realise their own strategies and goals.

In any value network, there are different degrees of resources and capabilities from different actors and they can be more or less powerful in this network. Structural partners are ones who provide the essential, non substitutable assets. Contributing partners are those that provide services to meet the specific network requirements. Supporting partners are ones who provide substitutable, generic services to the network. Structural partners are theoretically better positioned to exert control over the network than supporting partners.

7.3.3 Technology Design

Technical resources and capabilities are the components that the technical architecture is built with. But at the same time, the technical resources of the actors in the network impose requirements on the technical architecture and it has to work with those resources (Faber et al). The technical architecture encompasses the delivery of service as well as the connection of different actors to work together. Different performance measures are also part of the technology design such as the type of underlying network, the types of software, hardware and applications as well as personalisation of services.

7.3.4 Finance Design

The finance design is a description of how financial arrangements between different actors in the network are made. The intention of this value network is to capture revenue or monetary value. The set of financial arrangements between the different actors includes how profit, investment, cost, risk and revenue sharing are arranged (Faber et al).

The tariff structure is part of this arrangement and it is worth mentioning because this is the most visible part of the finance design to the end user. Revenues come directly from the end user but there may be other forms of revenue coming from grants from the government or from advertisements. Investments and costs are related to the design choice made in the technology design. Investment sources provide capital to the network while cost sources generate costs for the network. Risks that occur within the other domains will incur financial consequences. How the network copes with these financial consequences from risks is part of the financial arrangements.

The different design domains set out in the paper by Faber et al could be used to analyse possible business models in the mobile industry today and in the future PN environment. This concept would be a useful tool not only to look at the technological domains but also the finance domains.

7.4 Analysis of Business Models

The business model of today's mobile and wireless market is becoming more complicated. There will likely be more functions that a partner can fulfil and also new niches to be filled. New partners will be needed to fill the gaps and to contribute new ideas and expertise in this ever-changing industry. In a PN, different combinations of relationships between partners will result. This would probably be more complicated than what we have in today's mobile industry because of the additional functionalities of a PN and also due to the addition of new personalised services.

7.4.1 Service Design

The service design is the presentation of value to the customer. The service design is therefore the product or service that will be presented to the customer (Faber et al). Generally speaking, the service design of a network provider in a PN context will be to provide, for example, the following[132]:

- voice service
- non-voice service
- value added services
- customised applications

[132] This list is not exhaustive. It only provides examples of some of the services that are to be accounted for in the service design of the business model.

Voice services have existed for some time but the quality of voice services has improved a lot since the days of analogue mobile technology and these days, hardly anyone complains about the quality of voice services. This service is therefore an evolution of an existing service and the delivered service should therefore have either a similar or a higher quality than before. Further enhancement to voice services could include something such as voice recognition both as a convenience tool and as a security tool.

Non-voice services refer mainly to data type services that would also be presented as an evolutionary service that has been offered to customers prior to PN services. This means that customers have an expectation of the service. What is provided by the network provider should be comparable with what they have already experienced. To the device manufacturer, non-voice services have also presented many challenges. Device manufacturers will have the continued task of delivering well-designed and functional devices to users which offer good quality voice and non-voice services.

Other value added services are content services, transaction services, customer services, billing services, broker/aggregation services, location based services and downloading. These are considered new services and customers will not have any prior experience with which to compare. These are therefore revolutionary services. Customers will still have an expectation of each service and the network operator will have to strive to meet these expectations. What services are provided by the operator should be presented in a well designed package to users. The device manufacture is expected to provide devices that will give users high quality user experience with the new services and applications. These expectations may be in the form of service level agreements or service level guarantees. This is the level of service quality that is demanded of the operator.

A new feature that would be provided by network operators is probably that of customised applications. These are in fact personalised services that are catered to individual customers' requirements and needs. In order to achieve this, network operators are expected to work together with device manufacturers and other service providers to give customers the types of personalised services that they want. Once again, these can be classified as a type of radical new service and customers will not have any prior experience with them. Important parameters to note in the service design are the expected value, the perceived value, the conceived value and the delivered value.

The value proposition of the mobile operator is a complex one and although communications remains the core of their business, there are newly defined aspects that have caused diversification within the mobile operator's business. The mobile operator will still have to offer its traditional voice services (be it through the legacy network or through a new IP-network). However this product offering is no longer sufficient for the average user, whose knowledge of mobile services and applications has grown just as the mobile industry has evolved. Increasingly, mobile operators are taking up the additional role of service provider in the sense that they provide (either by making use of their fixed network group or with partnership arrangements) internet services as well as mobile service. In the case of the device manufacturer, users will probably expect to have some, if not all, of the following:

1) Different access types and seamless roaming through different types of networks
2) Extensive functionalities and applications built into the device.
3) User friendly interfaces
4) Longer battery life.

As the convergence of mobile telecommunication and the Internet amplifies, the greater the need will be for the mobile operator to step into this converged market. This converged market is characterised by mobile and Internet based services. Therefore, service provisioning, quite naturally falls into the scope of a mobile operator. Cost has and will continue to be the underlying factor whether users choose one product over another. Giving value to customers will become more important than giving a value product. Focus and addressing the market as a whole will be essential to keep costs down. Standard solutions will become the norm and special customised solutions will decrease.

The overall product offering to customers will change and mobile operators will have to take a bigger role in service provisioning and in providing seamless communication to users with different types of access and easy to use services. Both the mobile operator and the device manufacturer know that with new technologies entering the market, it is imperative that they adjust to cater to these. Some areas have been identified as possible future growth areas including:

- Instant Messaging Service (IMS) such as push services and gaming
- IP/Virtual Private Network (VPN) services
- Seamless services
- Machine to machine communication services
- Home communication services and digital home multimedia services
- Mobile healthcare
- Location-based information and context aware services
- New voice services using VoIP
- Personalised services

These services will require that both the mobile operator and the device manufacturer work with new partners and to diversify their current product offering. The business model is therefore also determined by the product offering of the mobile operator and will differ depending on which product type or offering it chooses to pursue. The service domain of the business model addresses the product elements of the mobile network operator's business model.

One significant growth area is that of digital home multimedia services. The digital home concept is becoming popular and mobile operators are trying to enter this market. Mobile operators are also trying to get a foothold in the digital service and content delivery value chain. The reason for this interest is that the mobile network operators are facing the risk of becoming bit pipe operators. Media companies want to make sure that their content is not distributed free-of-charge around the globe. There exist a number of different technical solutions that could bypass the mobile operator's present networks. Finding a good and sustainable business model for Content Service Delivery will give benefits to all interested parties.

7.4.2 Organisation Design

The organisation design is how the different firms and partners work together to provide the value service. The organisation design will also describe flow of services/routines within the company in providing service to the users (Faber et al). With respect to the firm's external organisation design, different partners are represented differently, and according to the amount and importance of their contribution to the final product or service. Structural partners provide essential, non substitutable assets. In the mobile industry, almost all products and services are substitutable from the network to the services. We will, however, take the network operator to be a structural partner for analysis purposes. From a network operator's point of view, examples of contributing partners would be the platform vendors and the mobile device manufacturers. These partners contribute to the specific network requirement. Structural partners are ones who provide the essential, non substitutable assets. Service providers and application providers would either be classified as contributing partners or as supporting partners if the role they play is a minor one. The different types of partners will work together in an organisation whose main goal is to provide the user with the product or service. There are different hierarchical levels in the organisation design because different partners will contribute differently to the value network.

Today there are generally speaking 3 different target customer groups that a mobile operator will serve:

- Private customers

- Business/Corporate customers
- Other mobile operators e.g. Virtual operators

Private customers make up a large proportion of the subscriber base. Unlike corporate users, private customers are very price conscious. This means that subscription prices and the prices of services must be kept low. With most countries having number portability implemented, it would be easy for private users to switch to another operator if what he is getting presently is not attractive. Pricing becomes the most important criterion for maintaining the number of private customers and thereby, market share.

Business or corporate customers are used to demanding tailor-made services. However, the reality of the mobile market is that voice calls based on the existing network costs far more than it would through an IP network. Therefore, more standardised services that ultimately address their needs will have to be supplied by the network operator. Pricing is not so much an issue to the business or corporate users, compared to the private customers. Services and quality of service are more important components of the corporate users' service.

The third group of users are other mobile operators. Mobile service operators or virtual operators buy capacity from the mobile network operator and offer services to their own set of customers making use of the mobile network operator's network. Network capacity and operation services are bought at wholesale rates but sold under the brand name of the virtual operator. Regulators seek to set prices in order to allow incumbent operators to have a reasonable rate of returns, and to prevent the incumbent and other operators from rent- seeking activities.

There is a need for a behavioural segmentation and a better customer understanding in the market. Many mobile operators will try to use different kinds of customer discrimination and focus on high value customers. The customers will be more important and usability testing in focus groups will be more common.

In relation to obtaining customers, mobile network operators have and will probably continue to make use of retail outlets and a dedicated sales force to acquire customers. Private customers are most likely to approach a retail outlet to browse and to find out about service offerings while a dedicated sale force will be required to cater to the needs of corporate clients as well as wholesale customers. Making the brand known will continue to play a part in the mobile industry and the more common ways of doing these advertisements or sponsorship of events. Other possible ways to communicate the brand are through partnerships, devices and portals.

To make services and applications more accessible to users, mobile network operators have started offering the users' built-in menu based access to data services which are pre-configured on their devices. This makes it simple for users and encourages them to make use of the services such as music/ring tone download and internet browsing.

Customer relationships are an important part of the mobile operator's service offering. Post sales service through a call centre, for example, is one such service.

The customer related business model element is made up of different aspect of what the customer requires and needs. The business model of the mobile operator will, as a result, be determined by which group of users it is addressing. Different business models may therefore exist to cater to different users with different technology needs and requirements and product wants.

7.4.3 Technology Design

The PN encompasses different types of access technologies. Different knowledge from different partners will ensure technology development. Many different types of technologies are involved in a PN. Therefore, the technology design for the PN is quite complicated. Some of the access technologies that will be encountered in a PN are as follows[133]:

- UMTS
- GSM
- WiFi (802.11)
- Bluetooth (802.15.1)
- UWB (802.15.3)

UMTS, GSM and WiFi are generally the more well-known technologies in the mobile and wireless world.

The IEEE Project 802.15.1 has derived a Wireless Personal Area Network standard based on the Bluetooth™ v1.1 Foundation Specifications.

The IEEE P802.15.3 High Rate (HR) Task Group (TG3)[134] for Wireless Personal Area Networks (WPANs) is chartered to draft and publish a new standard for high-rate

[133] These are only some of the access technologies that can be made use in a PAN environment today. Other technologies may include newer wireless technologies, sensor technologies and ad-hoc network technologies.
[134] http://www.ieee802.org/15/pub/TG3.html - cited 011205

(20Mbit/s or greater) WPANs. Besides a high data rate, the new standard will provide for low power, low cost solutions addressing the needs of portable consumer digital imaging and multimedia applications.

Other technical requirements that should be considered are:

1) Inter-connectivity
2) Inter-operability
3) Quality of service
4) Security and AAA
5) Infrastructure and hardware
6) Services and applications

A connected, heterogeneous network where services and applications are able to work is important in the technology design. Having functionality amongst different mobile and wireless networks will be part of the technology design of the business model. Operability within and between networks should also be part of the technology design. The technical resources available such as infrastructure and capacity are also important things to consider in the technical design. Quality of service throughout the different networks will have to be considered and a scheme of service should be offered to customers. Security is of the utmost importance. Increasingly more data containing personal information is shared electronically. AAA will have to be addressed and new methods to securely make transactions should be developed. The different technology partners will be able to contribute different technical attributes to the technology design. For example, the network operator will be able to provide the mobile network infrastructure and the services associated with it. Possible services include location based services and also disaster recovery management. The device manufacturer will provide its devices suitable for the operating environment, while the service and information provider will provide application and software technology to the value network. There are many components to technology design and these will have to be separated into different categories to enable clear analysis.

Technology elements are related closely to the technology design of the network operator's business model. Many mobile operators around the world operate dual-band GSM networks. Enhancements to the GSM network's capability in the form of High Speed Circuit Switched Data (HSCSD), GPRS and EDGE have been made. 3G networks will most probably only cover urban areas in the country with the operator falling back on its enhanced GSM networks in other areas. 3G networks have cost operators a huge amount of money, from license fees to the deployment and operation of the network. Several operators have built joint networks in order to keep deployment and operation costs at a minimum.

The introduction of other solutions such as WiFi will add to the complication of network interconnectivity required to ensure that users get seamless service. VoIP over WiFi will be a serious threat to voice revenues if network operators, both fixed and mobile, do not get into this market.

Self organised and ad-hoc networks will also be a part of this new market. While technology presents technical challenges for operators and device manufacturers alike, it should be simple and cheap for users. For the device manufacturer, the technology design is usually related to what the operators decide to do. Also, in the PN, as new technologies will increasingly become included, the device manufacturer will have to look for new ways to integrate different network technologies, and at the same time, provide for services and applications linked to the network operator's plan of action

Interconnectivity between different networks will mean seamless handover and handoffs for users. Interconnectivity between different operators is solved by roaming agreements. This also means that network operators have to integrate their billing systems in order to accommodate for this. The future of the mobile industry is one in which different systems work together and appear as one, whether it is mobile, fixed, the Internet or other new solutions.

Integrating these technologies and making it simple for customers to use is the future of the mobile industry.

The core capabilities and resources of the mobile operator will determine its basic infrastructure and what it can offer to users. Core capabilities may be "a set of differentiated skills, complementary assets, and routines that provide the basis for a firm's competitive capacities and sustainable advantage in a particular business" (Teece et al 1997). Together with the available resources, core capabilities will play a part in determining the direction of the mobile network operator in terms of its future business. Resources are defined as the assets available and anticipated for operations. They include people, equipment and facilities.

The infrastructure related elements are associated with the organisational design of the business model. The operator will have to make use of its previous experience in setting up a new network such as when GSM was first introduced and to introduce new services.

With new services and also new types of accesses, an important consideration will be that of its infrastructure and resource capabilities. The mobile operator possesses much experience and also expertise in several areas. Traditionally the mobile network operator has dealt with activities such as:

- Improvement and maintenance of the network
- Customer care
- Service provisioning

Today, as the mobile operator moves into a new converged industry, the traditional activities will not be enough to sustain it. A strategic position in the Value Network today is control of the customer interface. The operators are not likely to give up this position although there are threats from device manufacturers, portal owners content and payment providers.

Over the years, infrastructure and operations have been improved and upgraded as new technologies and enhancements became available. Maintenance of operations is also something that has been established within the network operator's domain.

Customer care is part and parcel of the network operator's service. Users will make use of this service as and when it is needed and experience with dealing with customers through such a service has on one hand improved service, and on the other, taught the network operator how to tackle more common problems that could occur with the user. This has improved human response to situations and therefore a valuable addition to the core capabilities available within the company.

Service provisioning is increasingly becoming the job of the mobile network operator. As the convergence of mobile technology and the Internet becomes a reality, service provisioning becomes an integral part of the mobile network operator's core capability. Service provisioning in the area of mobile service is something that has always been part of the mobile operator's core infrastructural capability and will probably continue to be so in the future.

The resources of the mobile operator will be further enhanced with partnership agreements. This has been a growing trend with data services where partnership agreements were made between the mobile operators and software developers, content developers and application developers for new data services and application on their mobile portal. As the mobile operator moves from being a pure network operator to a service provider, the trend is to create partnerships with others to increase content as well as coverage (geographical). Partnership agreements and business relationships allow the mobile service provider/network operator to offer value added services such as mobile TV, mobile banking and to differentiate service offerings to potential users. It also allows the mobile service operator/mobile operator to offer bundled services such as mobile with fixed and WiFi access as a package.

7.4.4 Finance Design

The finance design consists of the financial arrangements that exist amongst the different members of the value network. The set of financial arrangements between the different actors includes how profit, investment, cost, risk and revenue sharing are arranged. The aim of the value network is to gain revenue from the value product. Any type of financial transaction between members of the value network is part of the finance design of the network. Transactions occur when partners exchange products and services and a financial exchange takes place.

From the customer or end user, financial exchange also takes place whereby the user pays for the service or product received. The structure of this exchange is one of the considerations to be made in the finance design of the value network. The way that charges are made and the amount are important concepts that the provider would have to deal with. This, of course can already be seen from transactions between users and network providers where different tariffs are offered. Tariffs from fixed monthly to pre-paid are different ways that different segments of the market have to be addressed by the network operator of today. In the PN concept, where different networks are accessible by users, the charging mechanism would be different from what it is today and a new finance design with respect to this would have to be made.

Other aspects of the finance design that have to be considered are investments and costs. Capital investment and operational costs are related to the technology design license/fees and will be determined by the choices made in the technology design of the value network. Government grants and allowances will also contribute to the finance design. The finance design of the value network is considered to be the bottom line in which it can operate. And this would have to be carefully designed to reflect the many facets of financial transactions within the network.

The finance elements are a part of the finance design of the mobile operator. The finance elements are made up of revenue and costs. The mobile operator is able to earn revenue from different groups of customers such as private customers, corporate clients as well as wholesale customers who are mostly other mobile operators. Although the revenue from voice services is decreasing, it is still the major contribution to revenue streams. Data services revenue is on the rise but still not up to the levels of voice services. The number of subscribers and revenue continues to grow but mobile operators are seeing less and less revenue per user[135]. However, with 3G, some operators are seeing higher than average returns. Depending on the take-up rate and price stability of 3G services, the ARPU (Average Revenue per User) for 3G may be

[135] Information was obtained from a newsletter sent by telegraphy.com. http://www.telegeography.com/products/global_comms/index.php - cited 201005

quite attractive for operators[136]. Mobile operators must continually look at new ways of generating revenue and at the same time keep costs down. Continual market segmentation and knowledge of user patterns and profiles are important for operators to know.

Costs are also a part and parcel of the finance elements of the mobile operator. Costs are incurred when the mobile operator sets up a new network, maintains the network and upgrades the network. Costs are also incurred in technology research and development and also in obtaining operating licences. Costs are determined by many different factors such as:

1) IT platforms and technical infrastructure development
3) Operator's service level
3) Invoicing routines
4) Advantages of economies of scale

Costs differ from one operator to the next, depending on the focus area of the operator's activities, its business interests and customers as well as services provided. The finance domain and its elements are therefore seen as the bottom line of the business model where decisions made in the other domains and elements will affect the finance domain and its revenue streams and cost structures.

7.5 Present Day Mobile Business Model

In today's mobile/wireless industry, we can generally classify different members in the following categories, as shown in Table 15[137]. This has been adapted by the business ontology for e-business models specified by Osterwalder and Pigneur in 2002 (Osterwalder and Pigneur 2002). However, instead of their original 4 categories, 3 have been used here, the exception being that of regulation. This has been done because though regulation affects the business scenarios of members in their value creation process cannot be considered as part of a business model. Regulation sets up the legal and social framework that actors have to comply with but does not have any direct participation in the actual provisioning of services. Standardisation activities done by Standards Development Organisations (SDOs) will also influence the mobile industry. Again, the influence of standardisation is an indirect one. But because standards are undeniably tied to the final product, they do influence the direction of the mobile industry.

[136] IBID
[137] This table is not exhaustive and only represents some of the larger players in the PN.

This is but a representation of the many providers of products and services that work together today. This representation is dynamic and would probably change with future mobile technology and services. There are many other partners out there that have not been mentioned here and it just shows the magnitude of the industry and the great number of actors that exist here. Also, as the roles of different players become more and more converged, some will have more roles to play than others. There will be overlaps in the types of services provided and this is only expected as the industry evolves.

Communications	Technology	Services
Mobile Network Operators	Device Manfacturers	Portals
WiFi Operators	Equipment Vendors	Content Providers
Other Wireless Network Operators	IT Vendors	Application Providers
ISPs		Payment Agents
Fixed Network Operators		
Satellite Operators		

Table 15. Categorisation of different players in the mobile business model

An example is the simple model below, where a mobile network operator provides mobile service to the user, all this while making use of interrelationships within the value network to do this. This is the classic example that is used in today's mobile service provision.

At present, the mobile business model may be represented by Figure 31. In this model, the mobile network operator will be taken to be the main customer facing unit of the value chain. Other members of this model are the portal/ content aggregator, the service providers, the ISP, the mobile device manufacturer, other types of network providers (fixed, WiFi and other mobile network operators) and the network equipment vendor. These are the main players in this particular business model but there are obviously other smaller members that have not been indicated here. The relationships between the different players are indicated by the arrows drawn, and the different services and revenue exchanges are also indicated. What is important to note here is that this business model represents the mobile network operator as the most significant member of the value chain. This model is dynamic in nature and changes can and probably will occur. Although different actors are all looking at increasing revenues, the mobile network operator seems to be in the best position to create new business other than its traditional core business of mobile service provisioning.

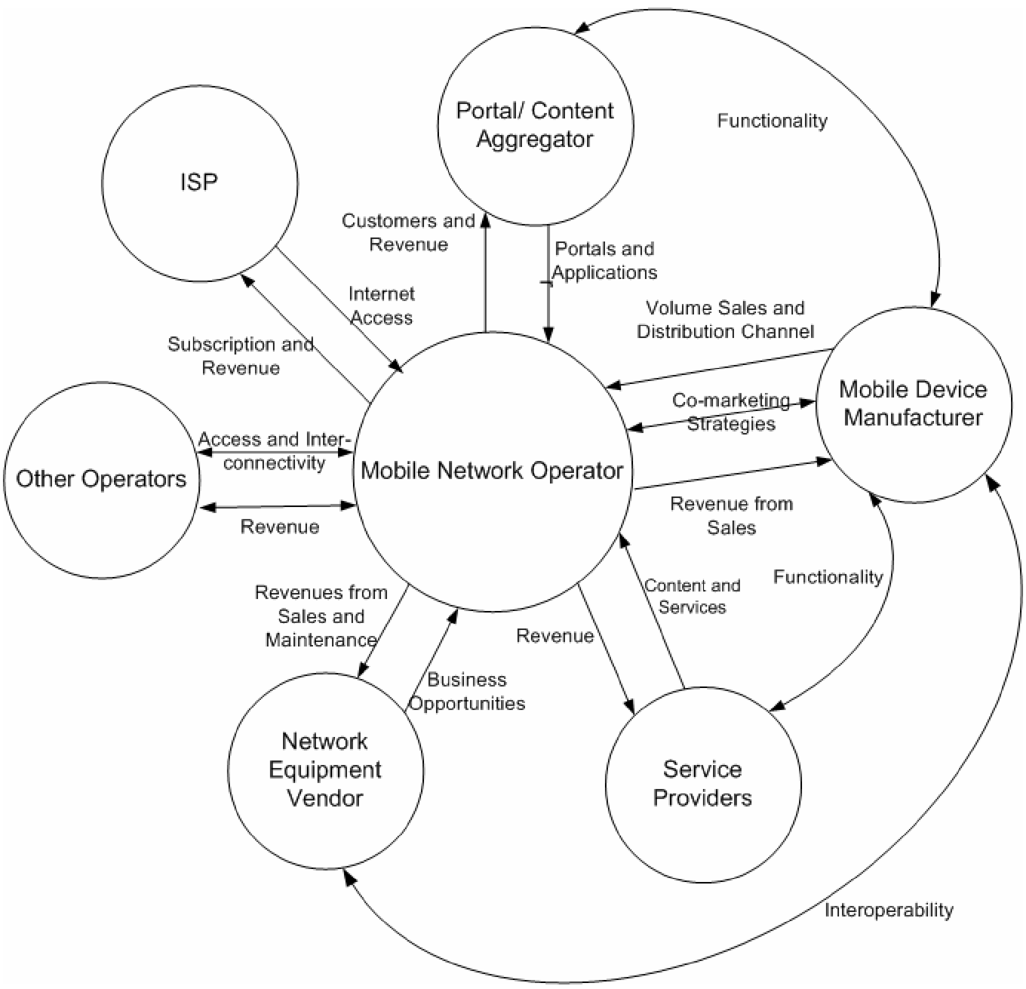

Figure 31. Business model of today's mobile industry

As the mobile industry moves towards 3G and data services, the mobile operator is likely to look at taking over some of the functions that are now performed by other actors. This is the natural way to go for the mobile operator as experience is gained and costs of operation must be reduced to compensate for lower ARPU. Several functions that are held by other actors may soon fall under the domain of the mobile network operator. Examples include Mobile Virtual Network Operators (MVNOs), portal and content aggregation, payment services and also service provisioning.

This model is most likely to be valid for today's mobile industry but it may still be valid in a PN environment though differences in the number of other members and the functions of members may change. It is, however, more likely that in the future PN, new business models will be presented.

The business model shown in Figure 31 is an evolution from the 2G or GSM business model. Earlier business models were simpler because there was little or no data services offered to users. However as technology evolved and data services are increasing and becoming more popular, the business model can be represented by that shown in Figure 31. This is not to say that it is the only representation of the mobile business model today. Newer services and applications will change the partnership arrangements and business model of the mobile operator. It is also probable that this model would exist for a while as the industry transitions from a 2G to a full 3G network and further on towards a heterogeneous network scenario.

From this model, many advantages seen to be held by the mobile network operator would make it difficult for other players to emulate in a short span of time. In a PN environment, however, the mobile network operator may have new functions or it may have functions taken away from it.

7.6 Analysis of an Operator's Business Models

A business model, as described earlier, includes a description of the inter-relationships that occur within a value network providing a service/ product to end users.

In this section, we will look at the general design aspects of the network operator and some of the functions it will take. The network operator of today follows very much from the 2nd generation network operator, with the addition of data services. The market for present day 3rd generation network services is still in its infancy and will continue to grow. Voice still plays a large part in the operator's revenue but even as volume increases, revenue is likely to reduce due to price cuts. The service offering of operators are changing with the new technologies that are being introduced and this gives rise to changes in the organisation as well as financial arrangements of the network operator. We will now go through the four design aspects in sequence (Sections 7.6.1- 7.6.4).

The future of the mobile industry is one that is personalised as well as being quite industry specific in its offering. General services like voice and simple data services would probably be offered throughout but value added services and applications over and above these general offerings will be what the members of the value network will be striving to provide.

Work at Lund Institute of Technology in Sweden has identified some services that could be of interest to mobile operators in the coming years, are (Claesson et al 2005):

- Broadband access
- Content accessibility
- Data security
- Digital TV
- IP telephony
- Music on demand
- Online gaming
- Online storing
- Socialising services
- Tailored services
- Video on demand

By looking at these services, we will look at analysing what the business model for a mobile operator will look like in a PN environment.

7.6.1 Service Design of an Operator's Business Model

The figure below, Figure 32, shows what the service design of a business model should resemble.

An end user, because of past experiences or influences, would have a certain expectation of the new product or service. Coupled with other determinants such ease of use of the new product and tariffs, they would have a final perceived value of the product.

On the provider's end, the intended value of the product is first determined by the technology available and also the ability of the value network in providing this value. The delivered value will be determined by the value activities within the network and the technology that has been used in the creation of the product. In the ideal case, the delivered value would be higher than the perceived value, meaning that the end user perceives the product to be of exceptional quality. In the worst case scenario, the delivered value is less than the perceived value. This means that the product does not meet the expectations of the end user. In between these two ends is when the delivered value of the product is equal to its perceived value of the customer.

For each of the services that have been identified to be of interest to the mobile operator, the following table, Table 16, identifies some of the determinants of perceived value of the customer. The perceived value is made up of past experiences as well as other determinants including experience from other products.

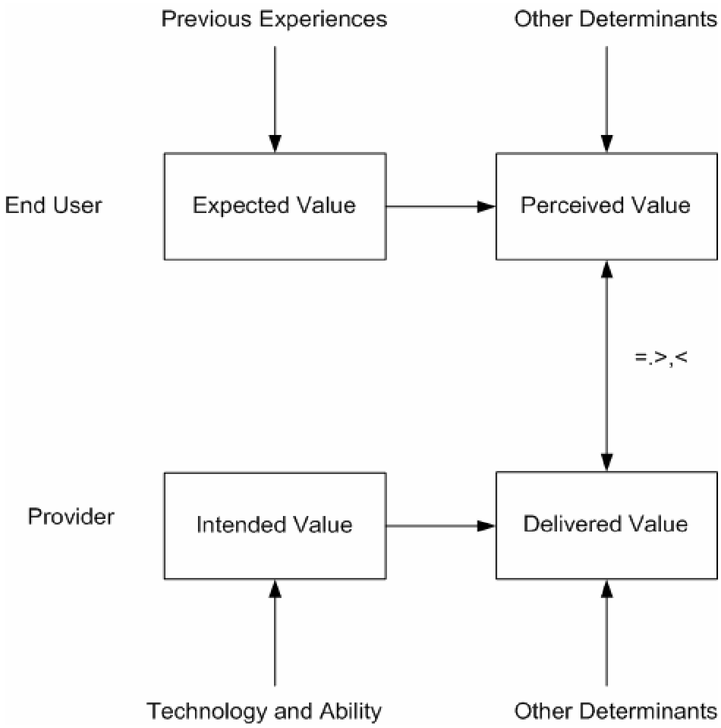

Figure 32. Service design
Adapted from (Faber et al 2003) and (Parasuraman et al 1985)

Service	Determinants of Perceived Value
Broadband access	Experience with fixed broadband access
Content accessibility	Experience with fixed Internet and previous mobile Internet
Data security	Experience with fixed and wireless Internet security
Digital TV	Experience with terrestrial TV and mobile-TV on trains and buses
IP telephony	Experience with fixed line telephony and present day mobile telephony
Music on demand	Experience from CDs, radio and downloadable music
Online gaming	Experience from PC games and console games
Online storing	Experience from fixed Internet
Socialising services	Experience with fixed Internet services and also other non-Internet services
Tailored services	Experience with personalised Internet services and push services
Video on demand	Experience with fixed Internet video services and non-Internet video

Table 16. Determinants of perceived value

The determinants of the intended value, the other determinants that go into the expected and delivered value are as shown here in Table 17 and will probably not vary so much across the different services.

Other Determinants of Expected Value	Determinants of Intended Value	Other Determinants of Delivered Value
Tariff and Cost, Bundled Services, Context of usage, Ease of Use	Technical Available and Ability	Technology and the Value Network Contribution

Table 17. Value determinants

The aim of the service design is to come up with a service or product that has a perceived value which is either higher or equal to the delivered value.

7.6.2 Organisation Design of an Operator's Business Model

The way the different actors in the value network work together is the basis for the organisation design. This describes the value network that is required in order to deliver a service or product to the end user.

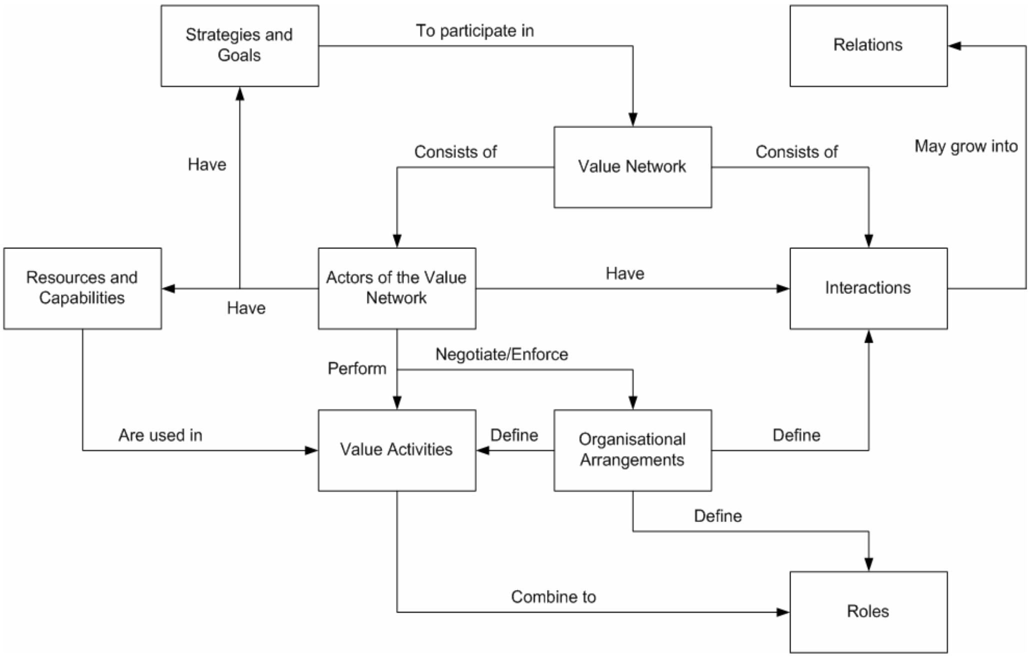

Figure 33. Organisation design
Adapted from (Faber et al 2003)

Figure 33 shows the activities that take place in the organisation design. Each actor in the value network is different. Each will have their own strategies and goals, and resources and capabilities. These in turn will determine how much they will contribute to the product of service. The different contributions that are required by different actors will determine the value activities that they have to perform in order to deliver the service or product to the end user. The actors will interact with one another and different degrees of relationships and roles will result in organisational arrangements that are complex and with different responsibilities from different partners.

For each of the services that have been identified earlier, the network operator will have a different set of:

1) Resources and capabilities
2) Strategies and goals
3) Value activities
4) Organisational arrangements.

The services are different and so the organisation design for each of the services would also differ. With that in mind, we will try to analyse the organisation design of the operator's business model. Table 18, shows an example of how the organisation design of the business model for each of the identified services could be.

Service	Operator's Resources and Capabilities	Operator's Strategy and Goals	Operators Value Activities	Operator's Organisational Arrangements
Broadband access	Mobile network already in place, knowledge of charging principals, trained personnel, research and development work in technology	Sign up more customers, Competitive pricing, provide new services and personal services, partnerships and alliances with related partners	Provide network services including broadband access, make sure network is operational and quality of service is in place	Collaboration with service providers and content providers to provide customers with good quality and useful content, work with platform vendors, hardware/equipment providers and device manufacturers
Content accessibility	Experience in providing content, large network already available for use, technical personnel	Provide combination packages of access and content to customers, give new and exciting content to users,	Content providers through work with content providers, work on interoperating with other access providers to provide seamless connectivity	Agreements with content providers in place,
Data security	Experience with mobile security, technical personnel	Provide good data security measures, choice of level of security offering	Work closely with data security providers in developing new measures for customers needs	Collaboration with data security providers and in development of new policies in line with customers requirements
Digital TV	Experience with telephony simple data services, technical personnel	Provide good quality digital TV service to users, provide personalised content to users	Work with content (TV program) providers and digital TV companies to develop service	Collaboration with digital TV developers and companies with content for Digital TV.
IP telephony	Experience with mobile telephony and data services, technical personnel	Provide telephony service with choice of traditional or IP. Ensure good quality of service of voice calls with IP.	Work with IP telephony providers and with device manufacturers in providing good IP telephony services to users	Business arrangements or alliances with IP telephony companies in developing technology, collaboration with device manufacturers in providing useful and simple devices to users
Music on demand	Experience with mobile telephony and simple data services, technical personnel	Provide easy to use music on demand services with simple charging methods. Large quantity of music available	Work with content (music) providers and advertisers in provision of music and related items	Collaboration with music providers to provide large quantity of music for users
Online gaming	Experience with simple data services	Provide fun and exciting games to users, simple charging methods, large variety of games available	Work with games providers to provide interesting games to users,	Collaboration with games providers, collaboration with device manufacturers for high quality graphics and sounds for good gaming experience
Online storing	Experience with simple data services	Provide storing facilities for users at reasonable prices, security and AAA should also be provided	Work with storage facilities providers, security companies should also be consulted	Arrangements with storage facilities for users to make use of. Collaboration with security and AAA companies
Socialising services	Experience with simple data services e.g. sms	Provide interesting socialising services for users, easy pricing model, large content available, secure transactions available	Work with different socialising services providers in providing different types and different categories of socialising services to users	collaboration with socialising services providers, arrangements with other types of social- related services e.g location based services and information services
Tailored services	Experience with corporate customer's requirements, technical personnel	Provide tailored, personalised services to users, large number of different services to choose from, high quality of services, trained personnel	Work with different content providers and application providers and also security firms to provide secure and large quantities of high quality content for tailored services, trained staff to provide personalised services	Collaboration with all types of content and application providers, security providers, developers of new content and services for enhancements of services for users
Video on demand	Experience with telephony and simple data services, technical personnel	Provide video on demand services to users, large quantity of videos, streaming of video should be smooth and enjoyable, cheap and simple charging model	Work with content (video) providers, storage facilities, high bandwidth (from own network or others)	Collaboration with different video providers to provide large selection of videos, device manufacturers to provide high resolution screens for enjoyable viewing.

Table 18. Organisation design of certain services for the network operator[138]

[138] This list is not exhaustive and there may be other entries to these that may not have been considered.

7.6.3 Technology Design of an Operator's Business Model

The technology design describes the technologies involved and the technical architecture in which the technologies operate in the provision of a product or service. There are several ways in which the technologies may be classified, e.g. according to different layers of the OSI, or according to technology in hardware or software. The method that has been used in this analysis makes use of classification according to the structure of mobile services. This is shown in Figure 34.

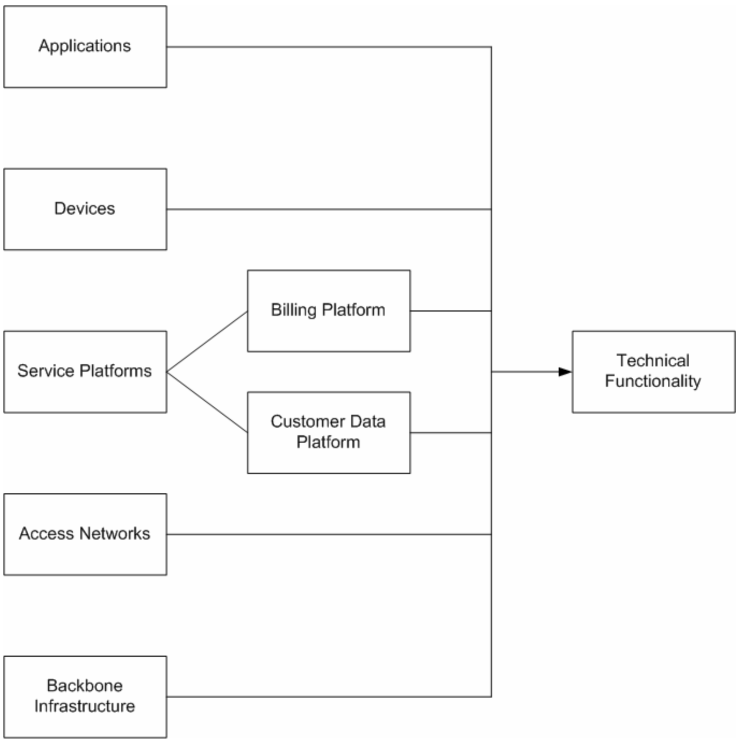

Figure 34. Technology design
Adapted from (Faber et al 2003)

Figure 34 shows the technology design of an operator's business model. The technological design variables are all important components of the technological design that will contribute to the technical functionality of the system. Each of the components, applications, devices, service platforms, access networks and backbone infrastructure makes up the technical architecture and describes a part of the technology design. The technological architecture of the product requires different contributions from the different components that are part of it in the technical design of the product. The technological architecture therefore gives the overall architecture and will determine if the system or product is, for example, centralised or distributed or interoperable or non-interoperable.

The technology design is an intricate weave of different components from the access networks to the backbone infrastructure, from the applications and devices. All are related to the technology of the final product. Services have not been included as a part of the technology but will be held as a separate component but one that would contribute to the overall technology design.

It should also be mentioned that the technological architecture of the product is one that is the result of planning and investment from the different actors in the value chain. The technological architecture, because of investments and other costs involved will generate costs to the value chain.

7.6.4 Finance Design of an Operator’s Business Model

The finance design is the financial arrangements between the different entities in the value network. The finance design is needed to see how money and other financial arrangements are made and how they are exchanged within the value network.

From Figure 35, it can be seen that there are different revenue and cost sources. The most visible form of revenue is from usage by customers. Revenue however can also be generated from government subsidies or tax breaks. Advertisement revenue is another source of revenue. The technology design will result in costs in capital expenditure and this would be another cost input to the finance design. Risk sources that come from the other domains for example technology risk or that of user perception will generate financial risks. And these financial risks will threaten revenue. The finance design is the bottom line of the chain, therefore any risks taken or revenue generated will affect the finance design.

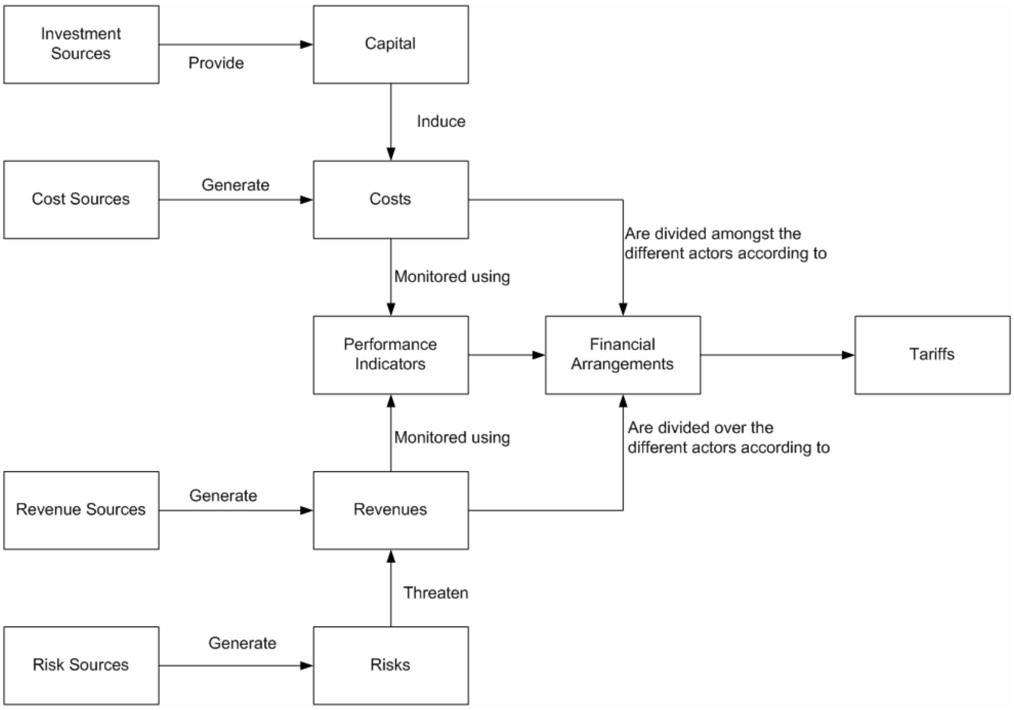

Figure 35. Finance design
Adapted from (Faber et al 2003)

7.7 Analysis of a Device Manufacturer's Business Models

The device manufacturer is probably the largest player in the mobile industry, after the operator. This entity provides all mobile phones, PDAs and other hand held user equipment that will enable the user to communicate. The device manufacturer has had to change with technology, just like other the actors in the industry. Research and development work in technology is ongoing within a device manufacturers sphere and this is evident in the number of new devices hitting the market all the time. The device manufacturer has moved on from 2G to 3G, but it does not mean that they no longer produce 2G devices. On the contrary, 2G devices are still the biggest revenue earners for mobile manufacturers such as Nokia and Motorola. From the simple mobile phone, the device manufacturer will now have to produce handheld devices that are mini computers, phones, and personal devices all rolled into one. Attractive design and simplicity of use are still important design criteria, but as data services gain in popularity, so is the number of applications growing in importance. Mobile devices are highly personal devices and each user's preference differs from the next. The mobile device of tomorrow will have to pack the different types of access types, wide variety of applications and services as well as hype and interesting design, all into one small, user friendly, long life battery into one complete terminal. This is no easy task and a lot of research and development work, within the device manufacturer's sphere as well as with partners and collaborators is still needed to fulfil all the different criteria of the next generation mobile device.

Some of the applications and services that are of interest to the mobile device manufacturer and some of which are currently under development are listed here:

- broadband access through both mobile and wireless air interfaces
- long battery life
- secure applications that deal with monetary transactions
- high resolution camera and video recoding functions
- context aware and location based applications
- IP telephony
- Simple user interface
- Cool design
- Sufficient memory

With the list of applications and services above, it is now possible to analyse what possible business model the mobile device manufacturer will have in the PN environment.

7.7.1 Service Design of a Device Manufacturer

As mentioned earlier, the service design is a combination of the different 'values' in the system. The user has certain expectations of the new product because of past experience and this expected value, with other determinants will result in a final perceived value of the product.

The device manufacturer, as it produces a new device, has an intended value of the product. This intended value, as mentioned earlier, is dependent on factors such as technology within the firm and also knowledge and activities conducted within the value network in the production of the device. This is, as opposed to the delivered value, which is the actual value that is the output of the value activities of the network (Faber et al 2003). The device manufacturer should, at the minimum, aim for the delivered value to be equal to the perceived value. The perceived value is the user's preconceived expectation of the product or service which is made up of the expected value plus other determinants. The delivered value is the value that the device manufacturer actually delivers to users. In the best case scenario, the delivered value will be higher than the perceived value of the user. This means that the quality of the mobile device exceeds the perceived value of the user (Faber et al 2003).

Service	Determinents of Perceived Value
Broadband access through both mobile and wireless air interfaces	Experience from WiFi and earlier mobile data accesses
Long battery life	Experience from earlier mobile devices
Secure applications that deal with monetary transactions	Experience from card transactions
High resolution camera and video recoding functions	Experience from earlier mobile devices and other digital equipment
Context aware and location based applications	Experience from fixed context aware programs
IP telephony	Experience from fixed IP telephony
Simple user interface	Experience from earlier mobile devices and other devices
Cool design	Experience gained from the design of earlier devices
Sufficient memory	Experience from earlier mobile devices and other devices

Table 19. Determinants of perceived value of the mobile device user.

For each of the services identified earlier, Table 19 shows some of the determinants of the perceived value (which is the adding together of the expected value (obtained from previous experiences with mobile services) and other determinants of perceived value of the customer with regards to a new mobile device.

The intended value is the value proposed initially by the device manufacturer and this is determined by the technology available as well as the technical ability available. The delivered value is the Intended value working with the technology available to the value network and the contribution from the members of the network (Faber et al 2003).

The service design should always aim at presenting a delivered value which is higher or equal to the perceived value of the user. The service design should take all the different determinants into consideration in order to achieve this aim.

7.7.2 Organisation Design of a Device Manufacturer's Business Model

The organisation design of the Device Manufacturer's business model depicts how the different members of its value network come together and work on the successful delivery of a product (Faber et al 2003).

Each member of the value network is different with its own resources and capabilities, which together with its own strategies and goals will engage in value activities with other members of the value network in order to deliver the mobile device to the end user. The members of the value network are able to negotiate and/or enforce organisational arrangements which define the value activities within the network. There are many diverse interactions taking place within the network and different roles and relationships exists amongst the different members of the value network (Faber et al 2003).

Corresponding to each of the services that were identified as being interesting for the device manufacturer to look at, the device manufacturer will have a different set of:

1) resources and capabilities
2) strategies and goals (both short term and long term)
3) value activities
4) organisational arrangements

This means that for each of the service mentioned earlier, a different set of each of the above exists for the different services. Table 20 shows the organisation design of the device manufacturer and summarises the different resources and capabilities, strategies and goals, value activities and organisational arrangements that the mobile device manufacturer has for the different services defined earlier.

Service	Device Manufacturer's Resources and Capabilities	Device Manufacturer's Strategy and Goals	Device Manufacturer's Value Activities	Device Manufacturer's Organisational Arrangements
Broadband access through both mobile and wireless air interfaces	R and D staff already working on this, knowledge of previous data access types e.g. GPRS	Provide different access types in one device at cost-effective prices.	Research and development activities to ensure that different access types are implemented and that inter-operability issues are solved.	Collaboration with the network providers and platform providers to ensure interconnectivity and interoperability is solved
Long battery life	Develop efficient applications that use less battery; make sure that functions on the mobile device are efficiently designed	Provide batteries that last longer with the higher power consumption of newer functions and applications	To provide higher capacity batteries for use in mobile devices by working with and contributing in research.	Collaboration with battery and fuel cell partners in research and development to develop the next generation of long life batteries
Secure applications that deal with monetary transactions	Make use of knowledge gained from previous financial services making use of SMS and how newer secure financial transactions may be safely developed for mobile devices	Provide secure applications and financial services through the devices. Device security must be ensured	Work to provide safe and secure devices and also work with application providers to see how the software and hardware can be made more secure	Collaboration with security firms working on new security features (e.g. iris recognition or thumbprint recognition) and also with application providers to ensure secure functionalities on mobile devices
High resolution camera and video recoding functions	Experience in older generation of mobile devices with such functions.	Provide high quality cameras and recording functions on new devices	Work with component providers and in the development of small sized but high resolution cameras	Collaboration and business arrangements with camera component providers
Context aware and location based applications	Experience with other data applications and with push technology	Provide applications based on context awareness and location services	Work with providers of context aware and location based services and to incorporate these applications into mobile devices	Collaboration and joint development of applications
IP telephony	Experience with data services and voice technology.	Provide telephony service with choice of traditional voice or IP telephony. Ensure that VoIP applications can be used seamlessly with mobile devices with WiFi access.	Work with the network provider, both mobile and wireless to come up with VoIP solutions that are beneficial to all partners	Business arrangements or alliances with IP telephony companies in developing the technology and application. Collaboration with network providers to provide solutions feasible to all.
Simple user interface	Experience from older generation mobile devices and development of new interfaces	Provider simple and not overly complicated user interfaces with mobile devices	Work with researchers in educational institutions working on user interface development and also component providers for device interfaces	Collaboration with universities and other research institutions doing work in usability and design of new user interfaces. Business arrangements with component providers
Cool design	Experience from older generation mobile devices and design team	Provide designs which are extraordinary and eye catching	Work with designers from fashion houses and other industries to come up with new, sleek and	Collaboration with fashion houses and innovative design companies but also developing of new designs in house
Sufficient memory	Experience from older generation mobile devices and development of new higher capacity memory devices	Provide sufficient memory space with mobile devices for storing photos, videos, mp3s and other applications	Work with component providers in the development of higher capacity memory chips for mobile devices	Business arrangements and collaboration with component providers in the research and development of memory chips specially for use in mobile devices

Table 20. Organisation design of certain services for the device manufacturer.

7.7.3 Technology Design of a Device Manufacturer's Business Model

The technology design describes the different technologies that are involved in the technical architecture and which will operate within the product or service. The device manufacturer has to consider different types of technologies in many different planes when developing a new mobile device. Table 21 shows just some of the different classifications of parts of the mobile device and the different technologies involved in each of them.

Classification	Technologies Involved
Air Interface	GSM
	WCDMA
	WiFi
	Bluetooth
	Other technologies
Operating System	Symbian
	Linux
	Microsoft
Applications	SMS/MMS
	Video conferencing
	Voice
	MP3 player
	Radio
	Other Applications
Hardware	Electronics and Components
	Screen
	Key pad
	Memory
	Antenna
	Other Hardware
Software	Control
	Scheduling
	Input
	Other Software

Table 21. Technology design of a mobile device

As we can see, there are many planes that a device manufacturer has to consider, in terms of the technology design. This is because of the multitude of technologies available to choose from. From all the different technologies that exist, choices will have to be made as to which go into the final technology design of a particular mobile device.

The technology design variables (which are made up of the different technologies involved in the design) are all important components that will contribute to the final technical functionality of the system, in this case, the mobile device. All of the components (Air Interface, Operating System, Applications, Hardware and Software) make up the technical architecture of the system and describes a part of the technology design. The entire technological architecture of the mobile device will require different contributions from each of the different technologies and different combinations of technologies will make up different devices. This is an indication of the overall architecture of the product and will be used to determine other factors such as whether the device will be inter-operable or non-interoperable.

In general, anything that has to do with technology will be part of the technology design of the product. The technological architecture of the final mobile device is one that has gone through rigorous planning and also investment in the form of money, time and research and development activities from all members involved in this value chain. It is therefore noted that the costs and investments that take place within the technology design will propagate within the value chain.

7.7.4 Finance Design of a Device Manufacturer's Business Model

The finance design of the device manufacturer represents the financial arrangements between the different members of the value network and how transactions will take place amongst them.

There are different sources of revenue and of costs and investments. This has been clearly represented in Figure 35. This figure showed the following:

- Investments sources provide capital
- Cost sources generate costs
- Revenue sources generate revenue
- Risk sources generates risks

With that, Figure 35 further showed that:

- Capital induces costs
- Risks threaten Revenues

All these different inflow and outflow of finances are monitored by performance indicators within each firm and within the value network. All these different financial relationships make up the finance design. The finance design is the bottom; that is it is the financial statement that shows the net income or loss within the value chain. Therefore, any investments, costs, revenue or risks taken in the other design domains will affect the finance design.

7.8 Discussion

The different design domains have clear connections with one another. Figure 36 shows some of the more important relations between the different domain designs and how one affects another. The relationships between the different domain designs show how inter-related and connected each of the domains are to the others and in describing the business model of each entity. A business model depicts the different inter-relationships within a company and with its partners and the relationships is not static. Shifts in technology paradigms and shifts in industry trends will lead to new business models.

The business models design domains as developed by Faber et al. and used here are hardly static in the real world. Variables change and relations shift resulting in a dynamic model that is constantly being adjusted. Balancing all these factors and variables is what creates a dynamic model. Changes in one domain will likely affect one or more of the other domains as seen here. The effect may not be direct but maybe an indirect consequence. By using the Faber et. al. model, it has therefore been possible to see that a business model describes different aspects of a complex network of relations and arrangements.

Business models and business modelling are seen to be evolving with the technology available in the market. Players have to constantly review their business models in order to reap in the most out of their business. With new technologies entering the mobile and wireless industry, the business models of players within this industry will change and evolve with the technology. How the individual company chooses to stand against these new technologies is determined by the business strategies adopted within the company. But the business model within the business strategy of the company will see to how the technology either disrupts or sustains the existing market.

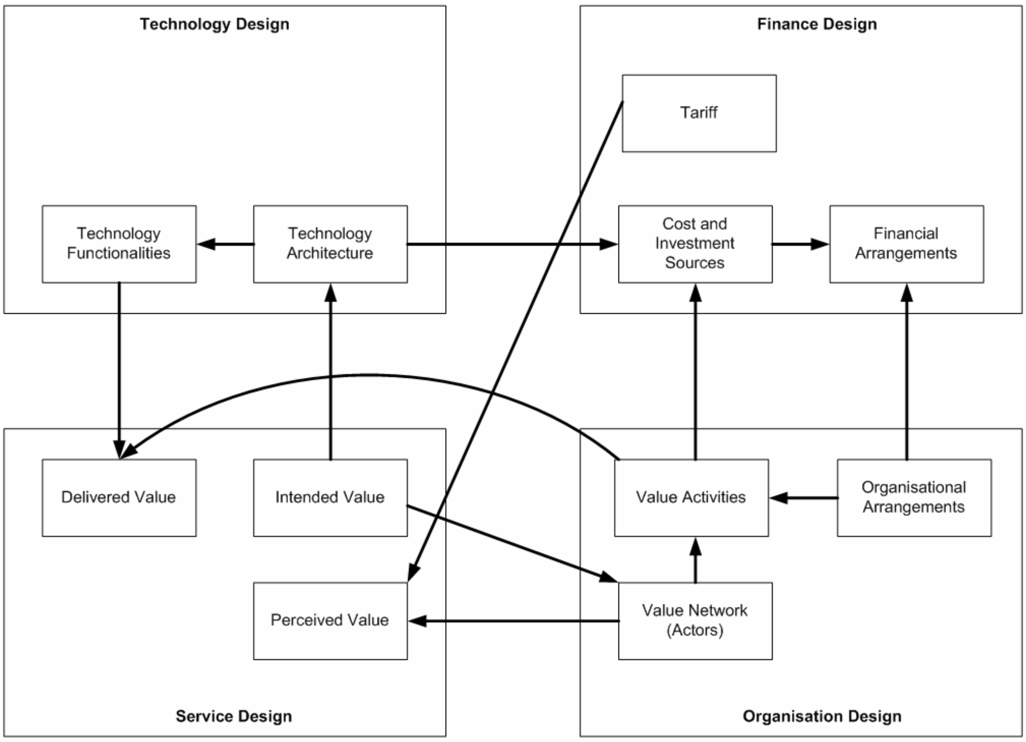

Figure 36. Important relations between the different design domains
Adapted from (Faber et al 2003)

The business models of two important players in the mobile (and wireless) industry have been analysed here. Making use of the theoretical framework put forth by Faber et al, the business models of each of these players has been separated into the service design, the organisational design, the technology design and the finance design. These four design domains describe the various relationships that take place within the value network in the creation of the final product or service. There are many relationships and processes within each business model and these practical examples show the complexity and inter-relationships within the value network.

8 Business Strategy

This chapter gives an overview on the differences between the concepts of business models and business strategies. This chapter has been developed in conjunction with the IST-MAGNET Work Package 1, Task 4 Final Deliverable and consists of valuable contributions and insights given by Rune Roswall from TeliaSonera Sweden.

Business models and business strategies are integral parts of the mobile operator and the device manufacturer alike. They represent the plans for the company moving forward and how it will approach the future, in terms of business, technology and other factors. One of the possible scenarios for the mobile future is that of PNs. PNs, as mentioned in Chapter 7 incorporate heterogeneity of networks as well user requirements to product services targeted at PN cases identified in the MAGNET project. Strategies aimed at PN, which encompass different technologies, both old and new, are therefore quite central to the discussion of what the future of mobile and wireless communications could look like.

8.1 What is Business Strategy?

Like business models, the definition of business strategy has also taken many different views. Porter defined strategy as the positioning of a company in the market (Porter 1985). Campbell, Stonehouse and Houston describe a business strategy as a process with the purpose of making a business fit into its environment (Campbell et al 2002). Strategy can in many cases be compared to a process as it comprises of different stages. In order to formulate a business strategy, one has to first gather information regarding the organisations internal and external environment. The purpose of this is to come up with an analysis of the strengths and weaknesses of the organisation as well as threats and opportunities that exist in the external environment. The strategy of an organisation will evolve with time in order to accommodate changes in both the external and internal environment and is therefore a dynamic process.

Porter, in his book, Competitive Strategy, identified three generic or fundamental competitive strategies that a firm could adopt (Porter 1980). These possible winning generic strategic approaches which can be used to better other companies in the industry are

1) Overall cost leadership
2) Differentiation
3) Focus

Table 22 shows these generic strategies and the commonly required skills and resources as well as requirements within the organisation. The final column lists the possible risks involved in each of the strategies, as described by Porter (Porter 1980).

Generic Strategy	Commonly Required Skills and Resources	Common Organisational Requirements	Possible Risks Involved
Overall Cost Leadership	Sustained capital investment and access to capital	Tight cost control	Technological change that nullifies past investments or learning
	Process engineering skills	Frequent, detailed control reports	Low-cost learning by industry newcomers or followers through imitation or through their ability to invest in state-of-the-art facilities
	Intense supervision of labour	Structured organisation and responsibilities	Inability to see required product or marketing change because of the attention placed on cost
	Products designed for ease in manufacture	Incentives based on meeting strict quantative targets	Inflation in costs that narrows the firm's ability to maintain enough of a price differential to offset competitors' brand images or other approaches to differentiation
	Low-cost distribution system		
Differentiation	Strong marketing abilities	Strong coordination among functions in R&D, product development and marketing	The cost differential between low-cost competitors and the differentiated firm becomes too great for differentiation to hold brand loyalty. Buyers thus sacrifice some of the features, services or images possessed by the differentiated firm for large cost savings
	Product engineering	Subjective measurement and incentives instead of quantitative measures	Buyers' need for the differentiating factor falls. This can occur as buyers become more sophisticated
	Creative flair	Amenities to attract highly skilled labour, scientists or creative workers	Imitation narrows perceived differentiation, a common occurrence as industries mature
	Strong capability in basic research		
	Corporate reputation for quality or technological leadership		
	Long tradition in the industry or unique combination of skills drawn from other businesses		
	Strong cooperation from channels		
Focus	Combination of the above policies directed at the particular strategic target	Combination of the above policies directed at the particular strategic target	The cost differential between broad-range competitors and the focused firm widens to eliminate the cost advantages of serving a narrow target or to offset the differentiation achieved by focus
			The differences in desired products or services between the strategic target and the market as a whole narrows
			Competitors find submarkets within the strategic target and out focus the focuser

Table 22. Generic strategies as defined by Porter
Source: (Porter 1980)

With these three competitive strategies, he identifies the associated skills, resources, risks and organisational elements that affect the competitiveness of a firm. Table 22 illustrates these three competitive strategies. Here business strategy is therefore seen as how a firm competes in the market or how it gains a competitive advantage over its competitors. Strategy can also be the act of defining or setting goals and objectives and to take steps to achieve and measure them (Kaplan and Norton 1992) (Osterwalder 2004).

Business strategies determine what a company can or cannot do and what it should and should not do. Each company will have its own business strategy and it is the business strategy component that decides on what to do with new technologies or products. The choice of whether to adopt a new (radical) technology as one that is complementary to or as one that is a substitute to the company's existing technologies and products is decided by the strategy of the company. How the company competes with others in the industry is also determined by business strategies. It is therefore important to look at business strategies of today's mobile operator and how business strategies could change with the introduction of PNs.

8.2 Business Model versus Business Strategy

Business models and business strategies are closely linked. Both terms are used interchangeably at times. However, there are differences between the two terms. We have already looked at the definition of business models earlier. Now we will try to make the distinction between business models and business strategy.

In Seddon and Lewis, strategies are treated as grounded firmly in the real world, whereas business models are abstractions of the firms' real-world strategies (Seddon and Lewis 2003). This is depicted in Figure 37. The 'abstractness' of business models as compared to the "real-worldness" of business strategies, described by Porter, lies in the fact that a firm's strategy is deeply rooted in that particular firm's competitive environment (Porter 1985). Magretta suggests that a business model isn't the same thing as a strategy and that business models describe how different components of a business fit together but they lack one critical dimension of performance: Competition (Magretta 2002). This is in line with Linder and Cantrell's definition, whereby they see strategy as being concerned with competition between firms while business models are more concerned with the "core logic" that enables a firm to create value for its customers and owners (Linder and Cantrell 2000).

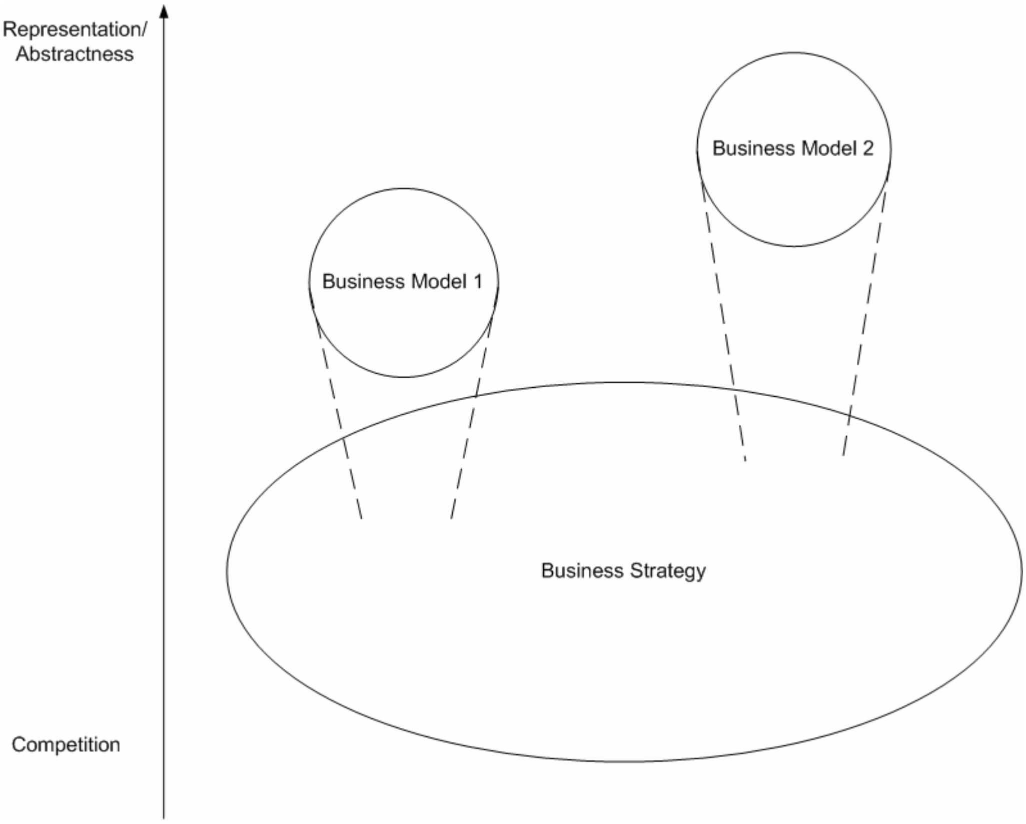

Figure 37. Business strategy and business models
Adapted from (Seddon and Lewis 2003)

Therefore, we see that business models are descriptions of how a firm does business and who its partners are. While a business strategy is a description of not only what a firm should and should not do, but also how it competes with others. Both components are important and related to each other and together will work towards the success of the firm. In a nutshell, the business strategy represents the way a company does business and essentially, how it competes in the market place. The business model, on the other hand is an abstract representation of this. It includes who the firm works with and the processes involved in obtaining the value product. There is therefore no doubt that business models and business strategies are closely related terms and Table 23 represents how business models and strategy are related.

	Business Strategy	Business Model
Definition	Pattern of managerial actions that explain how firms achieves and maintains competitive advantage through positioning	Blueprint of the firm's transactions with its external stakeholders
Main Questions to be Answered	How to position firm against rivals?	How to do business?
	What business to be in, i.e., what products or services to offer?	Which parties can be brought together to exploit a business opportunity, and how can they be linked to the focal firm to enable transactions?
	What customer segments to target?	What information or goods are exchanged among the parties, and what resources and capabilities are needed to enable the exchanges?
	What resources and capabilities (e.g. technologies to use?	How are the transactions between the parties controlled, and what are the incentives for the parties?
	When to enter the market and how to enter it?	
	How to compete, i.e. what kind of product market positioning approach to adopt (cost leadership and/or differentiation) and what kind of generic strategy to adopt?	
Focus	Internally/externally oriented: focus on firm's activities and actions in light of competition.	Externally oriented: focus on firm's transactions with others.
Value Logic	Value appropriation logic: creating and preserving a competitive advantage capturing more values than rivals.	Value creation logic: enhancing total value created (i.e. value created for all business model participants) by exploiting business opportunities.
Performance Measures	Value captured by firm (e.g. measured by ROA, ROS, Tobin's q, market value of firm, market value of equity).	Total value created.

Table 23. Business strategy versus business model
Source: (Zott and Amit 2004)

The difference between a business model and a business strategy is further developed by Zott and Amit (Zott and Amit 2004). They mention that that a business model describes "how a firm relates to external stakeholders and how it transacts with them", while the business strategy describes "a pattern of actions or decisions that explain how a firm achieves and maintains competitive advantage" (Zott and Amit 2004). Christensen also mentions that the business model can be a source of "competitive advantage or disadvantage" and it is the understanding of the "circumstances in which the company and its business model compete" that would put it apart from others (Christensen 2001).

The key difference that is picked out from a range of literature is inclusion of competition in strategy analysis. Competition is what sets business strategy apart from business models. Therefore, in this chapter, the definition of business strategy used is that it is what determines how companies compete with others in the industry.

8.3 Strategy of the Mobile Operator

8.3.1 General aspects

The mobile operator faces a future full of new opportunities as well as obstacles, depending on the way it sees it. Although the mobile operator's core competences are to build and manage mobile networks, this will not be enough in the future industry where converged services and technologies will be integrated. In the mobile value chain, it is likely that the mobile operator will continue to play a significant role. The mobile operator has already taken up secondary roles in service and content provision and transaction management.

Most often the mobile operator has a strong financial or credit position and will be an active player when it comes to finding good positions in the future value networks and Business Models. With this financial strength, several important attributes that the mobile operator could further develop would be:

1) Brand
2) Service differentiation
3) Simplicity
4) Trust and security
5) Customer service

In whichever area the mobile operator chooses to move into or to integrate into its present business, these features will continually be needed. A good brand name is a good differentiating factor which only catches the attention of potential users but also invokes a feeling of trust when users recognise the brand name.

Trust and security are particularly important features when it comes to financial transactions. This also applies when personal data is exchanged. Security aspects have been explored in Section 4.1.3 and 4.1.4 in Chapter 4. Mobile operators will have to work closely with financial institutions to develop processes where these two features are of the utmost importance. A working relationship with security firms will also be needed in order to provide secure transactions to users to build up secure practices. Financial transactions will become more popular in the future and mobile operators will have to compete for a share in this new service. .

Efficient customer service and help services, gained from past experiences should become an integral part of the mobile operator's business processes. This service can also be seen as a means of channelling the customer's requirements, needs and preferences to the mobile operator which the operator can then use to improve services.

Service and product differentiation are needed to address different corners of the market. Some users find certain services more important and useful to others. Also, to differentiate their service from other mobile operators, it is also possible that special or unique services will play a distinguishing role. With so much competition amongst mobile operators, price is one way to differentiate and with schemes such as pre-pay or flat rates with data services, mobile operators can then differentiate themselves from others. Of course, other service differentiation methods exist for example after sales service and customer care or bundling of services. The challenge comes when pricing schemes for different access are introduced. The PN pricing scheme will be more complex than compared to today's services and careful studies by the operator on different charging mechanisms will have to be done.

Simplicity and ease of use is something that users would want, even as the number of services and applications increases. This is one area where the mobile operator has an advantage over the other actors. The mobile operator is in the best position to integrate different services and to offer them as one simple package to users. The customer expects to be able to communicate and connect to the services over distances, at any time and everywhere. There should be no technical borders as to service availability and roaming. Life should be made simpler and not more complicated with new services. Services should be intuitive to use and technology should be invisible.

In order to survive, the future mobile operator may have to face key issues such as:

- Implications of a converged mobility–broadband environment
- Business refocus
- Network sharing
- Finding new and profitable business models.

The convergence of mobility and broadband will have to be considered by mobile operators. Operators will have to look at combining their mobile accesses with wireless accesses, both new and old, as well as the fixed network and how to use them to their advantage. The core business of just selling access will have to shift. New focus that skew away from the traditional core business of network provision will change to something that incorporates much more. Network sharing is one way to lower costs and could become part of deployment strategies of network operators (providing that network sharing is allowed by the government and that agreements amongst network operators are reached). Finding and developing new business models are important to the operator and profitability may be increased if new business strategies and business models are developed to address new products and services.

The traditional strengths of the operators in the value chain network have been their network assets, but now there is a tangible shift towards brands, organisation and market channels.

There is a consensus among network operators that long-term convergence of voice and non-voice networks must be more than an exercise in cutting costs. The main drivers of change will be to find values around mobile and broadband. The focus of the industry has to shift towards services and there will be an increased competition from players from other important industry sectors.

The future operator will mainly sell access and a range of applications, content, devices and services. Operators have to formulate new business strategies that in co-operation with its customers could derive values from intelligent edge applications and devices. In the long term, operators will have to evolve from being network service providers to being communications enablers.

8.3.2 Possible Mobile Operator Strategy

Porter's three different generic strategies that companies can adopt can be used to give an overview of how the mobile operator could compete in the market. (Porter 1980).

The first generic strategy is that of overall cost leadership (Porter 1980). The operator can, as part of its strategy, strive to achieve an overall cost leadership over competitors. This can probably be done in several ways such as:

1) Tight control of finances flowing in and out of the company
2) Network sharing
3) Strict labour count
4) New efficient process cutting away older expensive processes
5) Negotiating better deals with partners such as device manufacturers and platform vendors.

To gain cost leadership, it always comes down to the bottom line, which are mainly the expenses spent by the company and revenue earned by the company. To minimise costs and to maximise revenue earned is one way to achieve cost leadership over competitors. Controlling the company's finances tightly and to make sure that no unnecessary leakage of revenue occurs would play a part in increasing the amount of money earned.

Network sharing was considered appropriate after several network operators had to spend huge amounts of money on 3G license costs. With network sharing, two or more networks can make use of the other's infrastructure, thereby reducing their own network deployment costs. This, however, is very much regulated and arrangements are different in different countries.

Downsizing of the operations is another way that mobile operators have used to reduce their overall expenditure. This is another way that the operator can achieve cost leadership but it is almost always considered a last resort.

Old processes need to be changed and updated. Inventory and also information management systems could be replaced with newer ones requiring less time to use, thereby increasing efficiency and indirectly causing costs to decrease. Operators could also consider outsourcing certain functions such as call centre activities to companies which offer cheaper but high quality services.

The operator can also leverage on their position as the dominant player in the market to negotiate better prices of mobile devices from the device manufacturer, especially when wholesale is concerned. Because of the number of vendors in the market today, it is probably also possible to obtain better prices for platforms and other systems.

The second generic strategy mentioned by Porter involves that of differentiation (Porter 1980). With regards to the mobile operator, differentiation could come in the form of service differentiation or product differentiation. It must be noted however that in the competitive world of the mobile operator, drastic differentiation is somewhat difficult to come by. But some form of minor differentiation in offered services and also price may be obtained. Differentiation may comprise of the following:

1) Price and service quality
2) Different combination of product and services
3) Strong marketing and advertising activities
4) New subscription types which are more flexible
5) Availability of new, interesting services and applications that the user wants
6) New business model
7) Technologically superior network and related products
8) Personalised services
9) Strong brand name

Sure ways of achieving differentiation are with price and service quality. If prices are significantly lower compared to competitors, it is likely that it will attract new users.

Service quality is another option. If service quality is significantly better to that of competitors, it may also lead to new users. Differentiation may come when the mobile operator is able to ‘play around’ with their suite of products and services and to come up with packages that are different or are a level above what their competitors are offering.

Strong marketing activities and advertisements are also ways that can differentiate one company from the next. Marketing is part of what affects perception of products and if done right, can have a positive effect on a company's product offering.

Operators may also like to look at subscription types and how these can be more flexible to cater to changing services. Differentiation may come in the form of new subscriptions that offer more choices and are more flexible to user's changing requirements.

Product differentiation certainly comes from the availability of new services and applications that have not appeared in the market before and which are what users want.

One interesting way to differentiate a company from the others is with its business model. This includes, who its partners are and how it works with its partners to deliver the final product and also the different internal and external processes within the company that make it stand out from the rest.

For a mobile operator to have a technologically superior network will give it leverage over its competitors and is therefore another way it can differentiate itself from others.

Personalised services which can be offered to individual users may also be another way in which a company differentiate itself from competitors who offer more general and non-personalised services.

Differentiation can also come in the form of a strong brand name that users hold synonymous with good quality service and products. A strong brand name and a good reputation has to be built up, grown and nurtured through the many years of customer service and related activities.

The third strategic stance, according to Porter is that of focus (Porter 1980). Focus is somewhat difficult to describe individually as it encompasses both qualities from cost leadership as well as differentiation. When a mobile operator is focused, it means that it has a particular target or goal which it is working towards. This means then that the mobile operator would use its resources and capabilities as well as its strengths to compensate for its other weaknesses and thereby gaining a strategic foothold. Combinations of cost leadership and differentiation will be used to address a particular strategic target (Porter 1980). However, one problem that a company could face is that in becoming too focused, either on a particular market or a particular target, it may lose sight of other possibilities. Flexibility must exist so that the mobile operator is able to redefine its strategy and its targets to suit the fast changing mobile market.

8.3.3 Examples of Present Operator Strategies

PANs and PNs are likely to play a large part in the mobile operator's service offering in the future. For the mobile operator of today, one of the challenges is the convergence of different networks: fixed, mobile and wireless. Fixed network operators have been offering a wide range of services from networking to applications and software to clients in order to provide a more comprehensive suite of services and a one-stop-shop option. Vertical integration of services has played a part in the growth of the fixed network operator for some time now. With mobile operators moving into the same service offering, there are several things first to consider[139]:

1) Ability to integrate different network types
2) Availability of devices for use
3) Customised applications/software for each market
4) Simple charging and Billing
5) Differentiated Quality of Service
6) Personalisation of Services, Security and Privacy

Business model for operators will differ from one to the other. Depending very much on the strategy that the company has adopted, it would mean that the different operators could choose different aspects to pursue. This applies to 3G operators and beyond.

Table 24 shows different aspects of 3G that mobile operators could choose to adopt. 3G is not only about technology but also business strategy. The chosen business models and other social aspects are also important components. Most importantly, it is addressing what the user wants that would determine how successful the operator would be.

Different global companies have decided to build their future strategy over different areas of 3G and these can be seen here. While NTT DoCoMo has decided to concentrate efforts on building the market and to continually introduce new services, T-Mobile has decided on integration of networks to offer seamless roaming capability between different networks for their users. The mobile operator, 3, on the other hand has gone with content such as video clips and also content.

[139] There are probably other factors to consider but those listed here are of great importance to the mobile operator and their service offering in a PN concept.

Operator	NTT DoCoMo	3	T-Mobile
Goal	Building Market	Video Content	Integration
Aspects	Quality Handsets	TV, Video Clips	2G, 3G, WLAN
	Content-Video	Local/Global Content	Smart Phones, PDAs, PC Services
	RingTones	Affordable Rev/Mbyte	Email
	Coverage	Monthly Subscriptions	VPN
	Careful Pricing		Internet
	Economy of Scale		Different Charging
	Discount		Integrated Bill
	Volume based charging		

Table 24. Different 3G goals of different operators[140]
Source: (IST-MAGNET Oct. 2005)

Operators may have chosen one significant area to concentrate on, such as has been done by NTT DoCoMo, 3 and T-Mobile. However, it does not mean that other areas are not addressed. This is but a part of the company's strategy. Other areas of commercial interests would also be addressed, but may not be the main business focus. The business models will have determined partners and the firm's value preposition. But it is up to the strategy to decide how and where to apply the business model. These are part of the strategic choices that companies have to make regarding customer segments, markets (geography) as well as product choices. From these different strategies, different business models to address the strategies can be developed.

8.3.4 PN Roadmaps- Mobile Operator

In the eyes of the mobile operator, and with regards to technology requirements, coverage is king. There will be a need for partnering in a national and international scope to ensure high population coverage. Different alternatives should be evaluated and there is a need to create a step-by-step approach for the PN roadmap. Since the PN is all about ubiquitous access, this is very much in tune with that.

Several important technical upgrades are in the pipeline for the PN technology and different infrastructure roadmap needs to be defined. The Roadmap should cover PAN, P-PAN, access network connection options, PN networking, authentication & inter-working issues. To be future proof and to avoid future unnecessary upgrading, open interface requirements for PN Networks should be agreed upon and standardized PN development must be done in cooperation with Network Operators and Service Providers in order to solve network complexities and other inconsistencies.

[140] Some of the information here was supplied by Rune Rosswall from TeliaSonera, Sweden.

Local service/network providers are lucrative partners and should be considered, but there is a need to evaluate possible co-operations in terms of quality standards, business models, pricing and branding.

It is also observed that interfaces between Service Providers and Network Operators are not standardised and there is no existing de-facto standard for this cooperation. Cooperation with Network Operators and Service Providers will also be important for testing and implementation of new PN features. The Network Operators should develop new methods for control of their technical service quality. The PN is a ubiquitous and heterogeneous network that will probably have to be standardised for different operators, equipment manufacturers as well as service providers to interface with one another.

The process of collecting critical business information needed for the business model and for the market strategies may reveal additional business opportunities that PN partners together with its customers may wish to exploit.

The business models for PNs, are still evolving. They could be based on free connection, roaming and authentication services, capacity sales or service provision. P-PAN and PN Networks are unstructured networks suitable for occasional professional or community groups temporarily coming together and then quickly dissolve. There might also from a business perspective be viable health care cases, nomadic workers and smart home applications.

8.3.5 Strategy Requirements

A look at the global markets shows that future Service Providers will be looking for unique PN Business Models. Today there are many different models and flavours. Self organising models, Service Models and Hybrid Models are discussed in conference contributions and in other papers as well. A sure win business strategy has not yet been discovered. It is viewed that whole selling of network capacity will become popular among operators who do not want to get too deeply involved with the technology as such and it seems inevitable that this will eventually lead to a separation of service and network operations.

For PN-actors like Service Providers there will be low barriers of entry. Some players are expected to enter the markets with new and completely different business models, e.g. hospitals offering PN-services as a part of their medical health services. Also there will be global players like Google, Yahoo and many other service, application and content providers that will offer universal PN services for the mass markets. Peer to Peer (P2P) networking is expected to be the main force behind the future communication market's expansion. A high level vision shows cities, shopping centres, etc. offering free access for image reasons or to attract special customer groups.

The market should be driven by the customer demand. The increase in number of users, and especially frequent users, will be closely linked to availability of devices and the increase in the number of network connection points. The usage of Private Personal Area Network (P-PAN) and PN equipment in homes will increase substantially and the awareness and utilization of P-PAN will grow fast during the next couple of years. It is assumed that an estimated 40-50% of the shipped laptops and Smart phones will have support for P-PAN within 5 years[141].

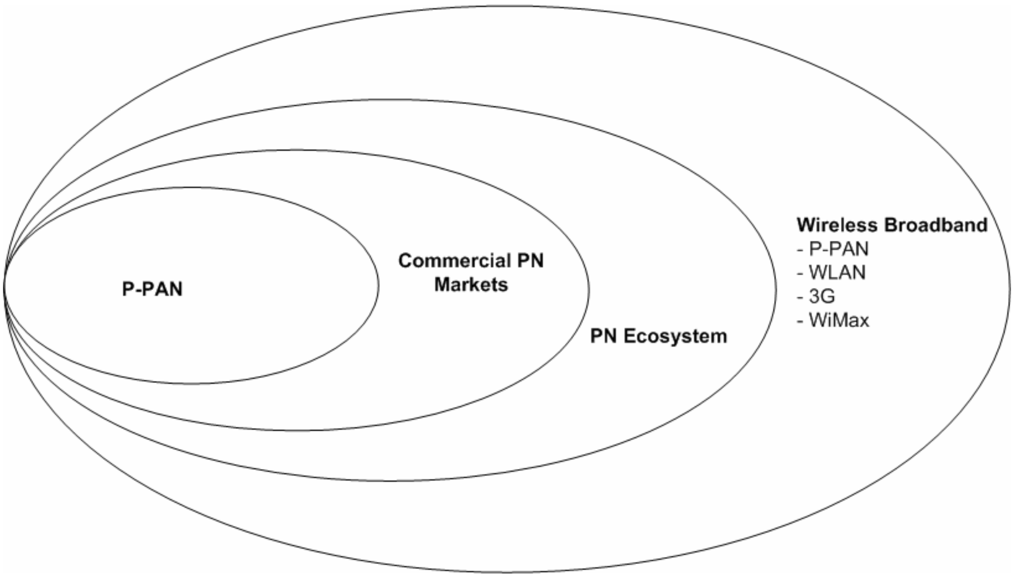

Figure 38. PNs as a component in the future mobile surrounding

Coupled with the customer demand is customer or user need. First of all the Users will require secure remote access to other P-PAN clusters through the PN. The technology should be easy to deploy and easy to use. Personal Network -technology should be reliable, with sufficient coverage and it should be affordable and within the means of the mass market. Competent support should be available when needed. There will be a need for ready-made turn-key packages with all the necessary technology included (terminals, printers, cameras and remote control devices)

[141] This number is based on analysis done by TeliaSonera, Sweden.

The strategy for ensuring the long-term business opportunities related to P-PAN and PN technology should aim to form a common view about the market development direction. A good strategy should outline actions, and guide markets to the desired direction. By developing a strategy or strategies, the P-PAN business model will be visible and open for the exploration of new opportunities. The strategy should shape the P-PAN ecosystem by “keeping all the doors open”, for co-operation with existing and new value network actors. Business Planners should develop scenarios, define use cases, outline user and system requirements, build and demonstrate pilots and co-operate in R&D mode for gaining adequate technical, user and market information. Figure 38 shows how PNs will work as a component of other mobile technologies.

8.3.6 PN Strategies

Many mobile operators today see the P2P and PN-opportunities. The strategies for offering such services, as well as breadth, depth and structure, vary dramatically between different operators.

What is interesting to note is that an operator has a strategy addressing the direction of the business and can adopt different business models for different types of services, even when working with a similar partner. In fact, the operator should do so, as each group of services requires different competences, and has a certain cost effect factor for the mobile operator.

Whereas in some cases an operator could be right to sit and wait for application developers or system integrators to develop services for very small niches, it would be foolish of the operator not to make an effort to tap opportunities from horizontal applications such as mobile e-mail.

Yet, the operator needs to have a clear strategy as to how its product portfolio is formed, how services are packaged, how they are priced, and how they find their way to potential customers. One special key issue operators are facing is the high barrier of adoption to many of the advanced services.

These barriers include cost of systems and integration, complexity, customization and lack of knowledge and resources. Operators must find ways to reduce such barriers, by, for example offering off-the-shelf products, offering single point of contact for sales, implementation and support, and assuring simple integration and low required investment (including financing if necessary).

A good practice has proven to be to target the existing customers by offering easy-to-sell products to the account managers and sales personnel. Also bundling existing offerings with new ones, thus getting the customers to experience new services, can be recommended. When it comes to new customers, operators need to show clear improvement to critical business processes, reduce customer implementation effort with turn-key solutions, and use smart partnering to match the target customers and partners.

8.4 Operator Business Opportunities in PNs

8.4.1 The PN Business Model

MAGNET is all about PNs. A PN is the total network made up from P-PANs and an interconnecting infrastructure. Communication within a PN can be anything from short range communication between personal devices (e.g. between a laptop and a mobile phone) to wide coverage communication such as UMTS. This depends on the available infrastructure as well as personalised inputs from the user. Being a personal network, available choices are up to the user. The business model in a PN environment has been categorised into that of:

1) Self-organised
2) Service-oriented
3) A combination of Self-organised and Service-oriented

Figure 39 shows the differences between each of these definitions.

The self-organised model is one where no financial exchange takes place, for example two users connecting to each other's devices using Bluetooth. It is also possible that when a user connects to the WiFi network but does not have to pay for this service (it may be already paid for by his company or it belongs to a friend). This would also constitute a self-organised model. In a technical context, a self-organised network is based on its own capabilities and preferences in contrast to externally forced actions. By combining the economic definition of a self-organised model and the technical definition of a self-organised network, the self-organised business model is therefore one that is formed based on its own actions and is independent of any external chargeable resources (i.e. no financial transaction in the immediate sphere).

The service-oriented model is one where a financial transaction takes place, in this case, a payment by the user to the WiFi Service provider in exchange for connecting to the Internet.

The combination model would encompass both earlier models where a self-organised and a service-oriented model exist. This would probably be the most common case in a PN, where different types of communication will take place, either through a network operator's connection or through a personal peer-to-peer connection.

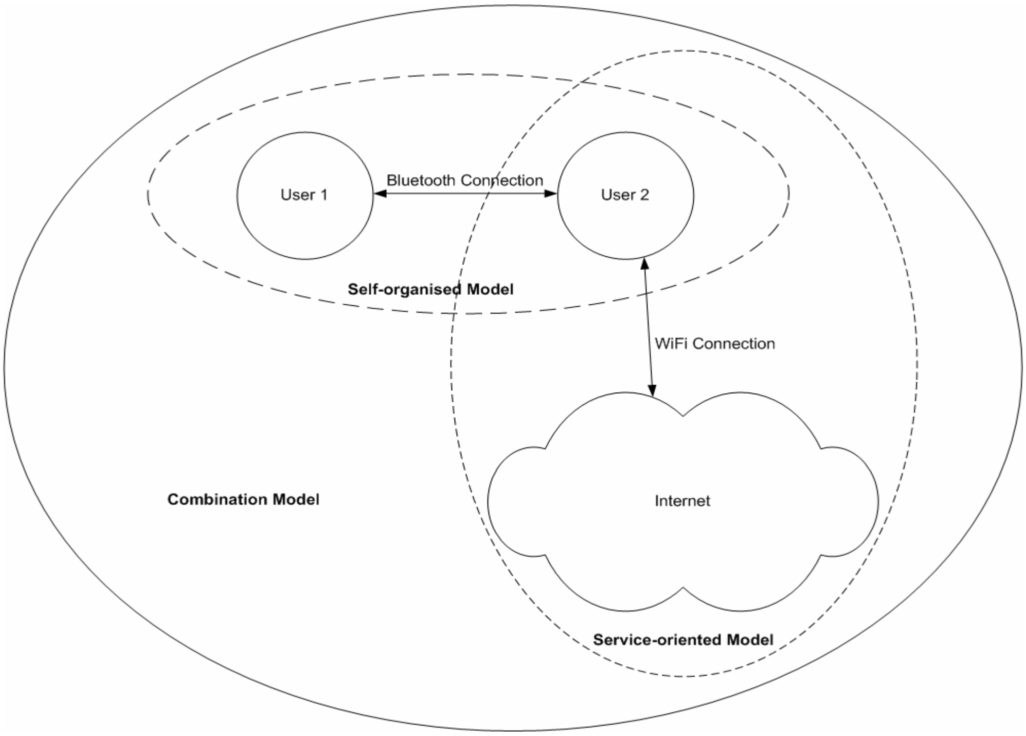

Figure 39. Examples of self-organised, service-oriented and combination models

Ad-hoc networks may exist in any of the combinations (Refer to Chapter 3). Since ad-hoc networks are defined as being wireless, self-organising systems formed by the co-operating nodes within communication of one another that form temporary network[142] with a dynamic and decentralised topology. Self-organised networks can therefore be PN agent networks in the MAGNET scenario (IST-MAGNET Oct. 2005).

The PN agent is a management entity located in the interconnecting structure (most likely to be the Internet) and keeps track of each Personal Node and all the clusters

[142] http://fismat.umich.mx/adhocnow/ - cited 280705

within a PN. Because there are many ways to implement a PN agent, it is viewed more as a concept than a physical node. This PN agent may be centralised and under the control of an operator or service provider or distributed over several operators. It can also be hosted by the individual users (IST-MAGNET Oct. 2005).

A self-configuring network, on the other hand, is one that is able to simplify the life of the user by configuring itself to the user's needs and requirements based on a set of pre-defined configuration rule-base or policies. This is in theory, the P-PAN network concept itself.

8.4.2 PN Opportunities

The P-PAN is a network that is able to automatically configure itself, based on earlier set requirements and information to give the best secure connectivity available. Its goal is to make things easier for the user. Now that we have established the three different types of business models for the PN, we can now continue to discuss possible opportunities that exist for the mobile operator. The PN agent is an example of a new opportunity for mobile operators. This will probably lead to an evolution of the present day business strategy of the mobile operator.

SWOT Analysis	
Mobile Operator's Strengths	**Mobile Operator's Weaknesses**
Mobile Operators are established and have well defined customer bases	Vulnerable capital assets
Mobile Operators have high competences in key PN areas	Mobile operators may not be able to handle complex PN business models and the combinations of products and services alone
Mobile Operators are financially strong	Mobile operators carries the risk of becoming a bit-pipe operator
Mobile Operators are able to solve the customer's needs for increased mobility	
PN Opportunities	**PN Threats**
Customers are demanding simple and cheap communication solutions	E2E solutions have complexities that have not been addressed yet
Huge synergy potential in integrated services and solutions	Management and suport systems not yet fit for implementation of integrated solutions
Service distribution over the most suitable access types	

Table 25. SWOT analysis of the operator's role as PN agent host
Source: (IST-MAGNET Dec. 2005)

Within a self-organised network, there will be a need to host a management entity. One possibility is that this is hosted with the mobile operator. Because interconnectivity between different clusters will most likely go through the internet (with different types of accesses e.g. fixed or mobile), the operator is in a very good position to cater to the requirements of a PN agent host. A possible generic SWOT analysis for mobile operators in a PN is shown in Table 25.

We see that the PN does give new opportunities and threats to mobile operators. Taking into account the PN opportunities and threats, as well as the strengths and weaknesses of mobile operators, several solutions may be drawn up. These are shown in Table 26.

Solutions	Mobile Operator's Strengths	Mobile Operator's Weaknesses
PN Opportunities	Combined market offerings	PN is perceived as a reliable and safe technology or concept
	PN Could give differential advantages	Partnering with other key players such as service, application and content providers
	There is room for aggregators and clearing houses due to the fragmented nature of the market	PN is a leading communications technology with a complete communications offering
	There is currently a lack of value-added PN services	
PN Threats	PNs will require heavy infrastructure investments without the promise of future revenue	Partnering with other players such as system manufacturers
	Faster and more targeted offers from competing technology operators	Simple pricing plan, at least in the beginning
	No dominant player in the market yet	The PN Business case is still not verified yet and therefore many possibilities exist

Table 26. Solutions to SWOT
Source: (IST-MAGNET Dec. 2005)

Possible mobile operator services in a PN utilisation environment include the following:

- Partnering (infrastructure) and roaming for extending PN coverage
- Whole selling of capacity and network services
- The mobile operator could act as a roaming and a service broker
- Clearing house for personalisation, billing, security and AAA services
- Service Level Agreements (SLA) for PN Users
- Offer seamless PN connections
- Offering a development zone where new facilities could be tested
- PN service provision

The different PN services mentioned are based on TeliaSonera's outlook on the possibilities of PNs. The dominant position mobile operators hold today mean that they have a significant share of the PN and are able to hold a strong position in the PN market. However, these operators will have to adapt to a new type of business where they are not just selling access or bandwidth. Service provisioning and other value-added services will be important in the PN market and the operator is in a good position to provide all these. The ability to develop new services and to change focus is likely to be key ingredients to the mobile operator's role in the PN.

The P-PAN/PN member groups might want to have the choice of multi-operator connectivity. In the short term, Network Operators might not want to open up their networks to P-PAN/PN-operators, but the MAGNET project and industry could influence the terms for Network Operator connections in Europe.

For the future there will be new business models related to network operator role. Network Operators could offer Edge routers/PN-Agents with P-PAN connectivity services in their networks. They could also offer managed PN services enabling easy authentication, authorisation, and billing for users with multi-access support.

Operators have good abilities to compete with ICT houses by offering total support for PN Services. They have a unique ability to make combined service packages from PN Network and other services. Another role could be to provide global PN roaming support.

As PNs and other new concepts in technology as well as new technologies are introduced to the mobile industry, they provide a multitude of new areas which old players can get involved in. For the mobile operator, being the player with the greatest market influence at this point in time, it is likely that related services would fall under their service offering. Network provisioning will not be sufficient to carry the mobile operator into the future but together with other services, the mobile operator will be able to provide a significant number of value-added services that are not part of their business today. In a PN environment, some areas (old and new) which could lead to new revenue streams for today's mobile operators could be:

1) Customer aggregator
2) Value network integrator
3) Content provider or content aggregator
4) Clearinghouse for Billing, DRM and Security
5) Financial service provider
6) Mobile, Internet and

7) Ad Hoc Network Service Provider (providing Hosting services, Edge routers, PN agents etc.)

The above list[143] mentions some of the possible roles that the mobile operator could go into. Some of these roles are already in place but others are new and could become a requirement in a PN scenario. As the industry actor with the most customers today, the mobile operator has a large potential base with which to work with. For the mobile operator, two key functions to concentrate on could be converged services and the personalisation of PN services for its customers.

One aspect to note in the PN scenario is that the network operator's role in the PN will probably depend very much on the type of industry it is addressing. As we move from a general market to one that is specialised and personalised in many ways, the business models will become more industry specific to address the needs of each particular industry. In MAGNET, these have been separated into 3 general cases, namely: magnet.care, smart@home and nomadic@work (IST-MAGNET Dec. 2004). These cases were chosen to address different aspects of a user's daily life. The cases are specific to certain industries. Magnet.care is related to the healthcare industry, smart@home is related to consumer electronics and home networking while the nomadic@work case is related to the broadcasting or journalistic world. They represent some facets of life that may be replicated in other areas with similar cases.

Industry specificity may result in the mobile operator and other players coming up with differentiated services for each case and for groups of users within each case. Of course, it all depends on the business strategy that the players choose to adopt and the business models developed. Within the general PN concept, the business model will still be used to describe the different operators' relationship with each other, their relationships with content aggregators, service and application providers, device manufacturers, platform and equipment manufacturers or providers and also other peripheral players in this mode. However, for the specific cases, different business models may be in place and therefore relationships between actors could differ for each of the cases.

The PN environment will probably create many more opportunities for both old and new parties in the value network. The roles of the old members are likely to evolve to different levels and new members are likely to introduce novel services to the PN.

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143 The author acknowledges that other new roles could exist for the mobile operator but have not been listed here.

8.5 Possible Device Manufacturer Strategies

Today's device manufacturers are facing more and more competition when it comes to the introduction of new devices. The traditional mobile phone has been replaced by devices such as Palm pilots and other such devices.

One strategic approach that device manufacturers engage in is that of alliances and industry led consortiums. These types of organisations are important to developing standardised features for mobile devices. At the same time, they could serve as avenues for exchange of knowledge and understanding between different device manufacturers and other industry partners.

Market segmentation has also played an important part in the strategy of the device manufacturer. There is no one single market. Different types of users demand different types of devices and features. The most common approach to this has been the business user and the consumer. However, consumers also present a large group and this has been further segmented into basic users, the gamers, the techie and so on. This categorisation is important to the device manufacturer in determining what types of devices are most suitable for each group.

As the number of access types increases, it means that device manufacturer will have to integrate different technologies into mobile devices. This proves to be quite a challenge as the mobile device has to remain small in size, yet provide enough battery power such that the user can make use of different technologies at different times. Part of the strategy of the mobile operator may be to choose only necessary access technologies for certain types of markets. This is in line with the different requirements of different market segments. For example, the business user will most likely get most if not all of the technologies integrated into mobile devices that are designed and developed for them while the basic user in the consumer segment will only likely get the basic GSM or UMTS technology in devices designed for them.

The strategy of the device manufacturer is very much linked to the strategy of the mobile operator. The mobile operator has had a role in the development of mobile devices. From section 8.3.3, we saw that operators have very different goals, such as integrating networks, video or building markets. Devices from manufacturers will therefore have to reflect the goals and strategy of the mobile operator. Intense competition amongst device manufacturer makes it necessary for them to develop parallel strategies to those of the mobile operators, their biggest customers.

8.5.1 Device Manufacturer Strategies in PNs

As is the case for the mobile operator, the PN too offers new opportunities for the device manufacturer. As mentioned earlier, the PN is likely to become industry specific with services that are specific to certain purposes. With that in mind, Porter's three generic strategy types will be made use of for analysing possible strategies for the device manufacturer in a PN context.

In order to obtain and to sustain overall cost leadership, the device manufacturer may have to consider the following:

1) Keep a tight control on finances flowing in and out of the company
2) Replace old facilities with newer ones that save money for the company
3) Tight control of labour
4) Get involved in alliances which lead to standardisation of parts and components
5) Look for new operators and sales channels
6) Good logistical and distribution system

One way to contribute to the overall cost leadership may be with a tight control on the expenditure of the company. Unnecessary spending could be cut in order to reduce out flow of money.

Old facilities that are deemed to be inefficient and costly could be replaced with newer ones that are more cost effective. In manufacturing, it is always technologically advantageous and efficient if facilities are kept up to date so that costs are reduced (in ways such as machine breakdowns and inefficient outputs).

Labour usage must be carefully regulated with demand and is one other way that the device manufacturer can decrease expenditure and thereby work towards overall cost leadership. This is, as in the case of the mobile network operator, usually a last resort move.

Alliances are a growing trend within the mobile industry with the goal of having standardised interfaces and other components for manufacturers. By participating in alliances that are involved in standardisation processes, device manufacturers not only have a chance to contribute and learn from partners, they are also able to, through alliances and working with suppliers, obtain better prices (due to competition amongst the increased number of possible suppliers).

With the P-PAN and PN, new operators are likely to come into the picture and not only fill niches left out by the dominant operator, but also to perhaps, compete against the dominant operator. This point to new sales opportunities for the device manufacturer.

Also, in PNs, there exists the likelihood that new operators (with other new technologies) will enter the market. This means that the device manufacturer, if it is able to keep up with the technological changes, will have new potential customers in the form of the new operators.

Manufacturers that are flexible in the production and distribution and that have good logistical systems to cater to changes in demand will likely have a cost advantage compared to other manufacturers that do not have this in place.

The devices that are available in the market today are diverse and cater to a wide variety of tastes and abilities. This is one aspect of the market that will probably not change with the PN. Devices are what users make use of to interface with services and applications and are therefore important to gain a strategic position in product differentiation. The following are some factors that may distinguish one mobile device manufacturer from all others:

1) Price and customer relations
2) Technology
3) Services and Applications leading to creative product design
4) New Business Model
5) Strong Brand Name
6) Good marketing and advertisement tactics
7) Research and development activities

Product differentiation may be achieved through competitive prices. Price differentiation is one of the most basic ways in obtaining a strategic advantage over competitors. Good customer relations may also be one way that one manufacturer differentiates itself from another. Although device manufacturers have traditionally operated behind the mobile operator (and not been the customer- facing unit) in the mobile value chain, its customers are the mobile operators and other sellers of their devices. Having a good customer relationship as opposed to one that is distant is one way to differentiate one company from the others.

In device manufacturing, one of the most important components is that of technology. Devices of today carry a multitude of applications and also access technologies (such as GSM, UMTS, and Bluetooth; and in some cases even WiFi). This all means that product differentiation may also come in the form of technology differentiation. The device manufacturer that is able to introduce a device that is both technologically advanced and at the same time user friendly is able to differentiate itself from its competitors.

The types of services and applications which a device manufacturer is able to develop and put on devices are also something that is able to differentiate one from all others. Creativity and new designs are essential in being able to differentiate one device from others. This could come in the form of shape, size, technology, user inputs or even how a product feels in the hands. The choice of operating systems, applications as well as usability of the device is also other important considerations that a device manufacturer will make in order to differentiate its product from others.

New business models will be needed to address the new mobile and wireless environment of the PN. This will mean that the manufacturer will probably have to work out new partnerships and business arrangements in order to address these changes. Relationships and processes within the business model may change from what they are today but these will have to be done in order to achieve some strategic advantage in terms of differentiation.

Strong brand names will continue to play a part in product differentiation. Some brand names possess a better perceived value compared to others. Brand loyalty from users is something that is important that has been built up over the years. Examples of retaining brand loyalty include clubs and user participation in new studies.

Good marketing tactics and aggressive advertising campaigns may also lead to product differentiation. This, with a good brand name is likely to make a particular device more popular. How a product is marketed is how a company can show its uniqueness and differences, and thereby its differentiation from others.

The research and development activities that a device manufacturer is engaged in are an important way in which product differentiation can come about. New technologies, new applications as well as new ways to market and sell products will contribute to the differentiation of the product from competition. Each device manufacturer is pursuing its own strategy in terms of technologies and business and research and development work in both areas are important contributors to differentiation.

The final strategic approach is that of focus. While the other two have dealt with “achieving objectives industry wide” through different practices, the final approach deals with “serving a particular target very well” (Porter 1980). With focus on a particular target, the device manufacturer is either able to achieve “differentiation from better meeting the needs of a particular target or lower costs in serving this target or both” (Porter 1980). Focus will result in the device manufacturer paying close attention to certain aspects of the product or the market but it comes with the risk that other important aspects may be neglected. Focus is a needed in that companies have a concrete goal to work towards, but at the same time, the manufacturer will have to be flexible and quick to make changes when needed.

8.5.2 Device Manufacturer Opportunities in PNs

The PN is a representation of the concept of being “always best connected” (Gustafsson and Jonsson 2003). In the MAGNET context, P-PANs and PNs represent new specialised areas which actors in the mobile community may enter. MAGNET has identified several user cases which simulate real life scenarios. The industry specific user cases and their related services and products will offer device manufacturers the opportunity to explore new arenas and to design and develop devices that are more specialised to each industry.

The strength of the mobile device manufacturer in the PN is that it has been in design and manufacture of mobile devices for specific target groups, e.g. business user and basic user. Incorporating knowledge gained from such market segmentation and also age differences, the mobile device manufacturer will probably be able to design and produce devices according to the requirements of each segment of the PN usage. Industry specific devices are likely to be needed and this therefore means that device manufacturers will have to make use of the R& D to work with other industry members such as applications developers and also taking the lead with new members (relating to the new industries) and making available devices that are the best for different sets of users.

One weakness that the mobile device manufacturer will have to address in the PN environment is the lack of certain technology skills and know-how. This will have to be compensated by with either employing suitable candidates or to engage in alliances and partnerships with companies that have experience in these areas. In the PN, because of the large number of technologies and cross industry expertise that is required for new devices, it is likely that the mobile device manufacturer will have to work closely with experts from other industries such as the medical industry in order to address the technological difficulties and challenges that will be posed from PN devices. The mobile device manufacturer will also have to expand its sales outlets to make their products known to a wider audience (especially target users in each industry specific group). This will mean having to set up new distribution processes as well as new partnerships and business models.

Opportunities lie in the design and manufacture of devices that are user friendly yet covering all necessary functionalities required by the user in each scenario. For example, in the medical industry, the possible requirements for a diabetic patient could include simple measuring kits to be built into the mobile device for easy reading of medical data and then subsequently sending of the data to the hospital and doctors for analysis or update. Opportunities could also take the form of device production with new user- interfaces and new functions that have never been done before. There are many areas in the manufacturer of devices that remain to be explored and therefore also present new possibilities for the device manufacturer. The idea of combining different types of ‘everyday’ appliances and tools with a mobile device catering to a particular PN requirement is something that remains to be explored.

The most obvious threats lie in the form of competition from other mobile device manufacturers. These competitors also have the industry and scientific knowledge from years of participating in the mobile industry. However, because communication is becoming so ubiquitous and with the growth of wireless technologies (WiFi, WiMAX, etc), it also means that the access will cannot be limited to only mobile technology access. This therefore points to the threat from new device manufacturers that have been involved in wireless device manufacturing; but not necessarily mobile device manufacturing. Threats may also come from other non-mobile device manufacturers such as medical equipment manufacturers in the healthcare case. If mobile devices can have medical functionalities in them, then it may also be possible for medical equipment to have mobile communications functionalities. This cross-industry development will see many new threats appearing and each will have to be addressed differently.

The mobile device manufacturer will therefore see new opportunities in the development of new devices for different PN environments. But there will also be different threats emerging because of the industry cross-over of the communications industry with others. The convergence of different technology know-how and expertise will present both challenges and possibilities to the mobile device manufacturer.

There are several possible things that the mobile manufacturer could do, with regards to their business strategies in the PN scenario:

1) Engage in strategic alliances
2) Employ relevant personnel with required expertise
3) Develop new business models
4) Design radical yet user friendly devices
5) Inter-industry standardisation
6) Industry specific analysis

Strategic alliances are one way in which the device manufacturer may want to tackle the new PN markets. Alliances may work towards technology standards or component or even product standardisation. With alliances, the device manufacturer will be able to not only learn from partners, but will have the ready support in the event of a standards war. Strategic alliances within the mobile industry are already in place (as discussed in Chapter 5) and we have seen the outcome of such alliances in mobile devices such as in the operating system and interfaces for interoperability purposes.

Lacking technical expertise and employees with relevant knowledge of the new technologies linked with PNs will be highly disadvantageous to the device manufacturers. It will probably be the case that people with required skills and knowledge be employed to fill this gap. Of course, transfer of knowledge may also come from alliances and other arrangements.

Part of the PN strategy of the device manufacturer will be to develop new business models. The challenges posed by new markets means that the device manufacturer will have to find new business partners to work with. This means that there will be a need to involve new members in the new value chain as well as to reconsider the roles of old members. The relationships between the entities of the former business model will probably change with the PN. At the same time, new relationships will be formed. With new relationships, new processes will have to be arranged. Business models will have to be dynamic as PNs are evolving and consist of very different requirements in the different PN scenarios. New business models dealing with each PN will probably be developed.

Part of the strategy of differentiation is to develop new devices that are going to catch the eye of the user. New types of input methods and ways of using functions on mobile devices will have to be looked at and new user requirements taken into account into the design of each PN centric scenario. As mentioned earlier, different cases will address different needs of users' everyday life. For each of these cases, differences in inputs, communication, functionalities and overall design will occur.

Inter-industry standardisation consortiums are probably going to be essential in a PN environment. Because of the convergence of different industries, such as the medical and communications or broadcasting and mobile coming together, there will be a need for inter-industry standardisation in order to standardise components and interfaces as well as products between very dissimilar industries. When manufacturers from each industry start producing parts or components for the other industry, it would lead to a need to have these standardised in order to make sure that there will be interoperability between the different elements. With standardised components and parts, it would lead more manufacturers being able to supply one another and this would lead to more competition in the industry as well. This will lead to cheaper parts and components and this low cost can then be passed on to users.

The device manufacturer will be moving into uncharted territory with P-PANs and PNs. It would therefore need detailed analysis of the specific industry. User requirements as well as technology studies will have to be carried out in detail. For example, with healthcare, devices manufactured for this industry will have to serve the user who can be of any age. In the same case, devices will also have to serve the needs of hospitals and doctors who are at the other end of the usage chain. Considerations from both parties will have to be taken into account and therefore industry specific analysis of each of the cases will have to be made, as part of the strategy going forward.

There are many different elements or pieces of strategies that the device manufacturer will have to assemble and put together. In the PN, opportunities abound. But at the same time, so do threats. The device manufacturer will have to consider carefully its strengths and weaknesses and to work at improving its weaknesses and at the same time adding on to its strengths in the new PN environment. Industry specificity will be something important in the PN and the device manufacturer will have to find ways of engaging in each of the specific industries.

8.6 Discussion

The differences between business models and business strategies are a subtle one. In this chapter, business models have been seen to be a subset of business strategies. Both the mobile operator and the device manufacturer have different sets of strategies with which they work with in order to either obtain an overall cost lead or to differentiate themselves from their competitors. Business strategies are needed to set out the scheme or plan of things to come for the company while business models are needed to make these plans possible.

The mobile operator is the dominant player in today's mobile industry; and in the future PN market, it could still remain a dominant player. The strategies that the mobile operator will develop in the PN environment will be significantly different from what they are today. New roles will have to be played and new services and business models relating to the PN have to be built up. The PN represents new opportunities for the mobile operator, but together with these new opportunities, there will be the appearance of new threats by foes, old and new. The new role as a PN agent is something that the mobile operator may consider as part of their new PN strategy as it represents a new focus for the mobile operator.

For the device manufacturer, the industry specific nature of PNs provides a wide variety of new opportunities but ones that have to be carefully thought through. New business models are going to be a requirement for device manufacturers to succeed in the PN market due to the cross industry convergence that is going to take place. User requirements are also going to play an important part in PNs due to the nature of services. The strategy of the device manufacturer will also have to adapt itself to the PN market.

Business strategies are what shape the future of companies. Present day business strategies of both the mobile operator and the device manufacturer will have to change in the PN market. Strategies must remain focused; however the ability to adapt new strategies and to change with the market is also strong points that the companies should possess. It is difficult to predict how PNs will be adopted in the future or how the mobile and wireless industry will change in the next few years. Both the mobile operators and device manufacturers will therefore have to remain vigilant to new potential disruptive technologies that are introduced and to weave these into their strategies. Strategies decide how companies will react to prospective disruptive technologies and how they will move forward with the technologies. The different strategies of different companies will become evident when faced with potential disruptions. Some companies will react by integrating the technology into their suite of products and services while others will choose outright to ignore it and continue to develop their products based on their corporate strategy.

Mintzberg and Lampel mention that “new strategies emerge from collaboration between organisations” and also from “competition” amongst organisations (Mintzberg and Lampel 1999). This is essentially what companies would have to engage in PN development and in other new technological concepts. They also mention that changes in strategy are the result of competition and when it is necessary to do so (Mintzberg and Lampel 1999). A new concept such as PNs and P-PANs will necessitate changes in business strategies.

The mobile and wireless industry is developing at a very fast pace and it does not discriminate over who should play a part in it. With technologies such as VoIP becoming more popular, providers of such services are not limited to operators. New operators making use of WiFi or other wireless technologies will enter the market and present themselves as competition to the mobile operator’s traditional playing field. The ability to adapt itself to changing roles and strategies is something that the mobile operator will need to posses while moving forward. Part of the job of strategies is to decide on how to compete in the market and how to gain a competitive advantage over others. Mobile operators and device manufacturers alike will have to take into account their strengths and weaknesses, as well as to access the opportunities available and the threats presented in present day market and the future PN market and to make strategic decisions based on these.

9 Discussion and Conclusion

9.1 Disruptive Technologies

The theory of disruptive technologies has been used extensively to consider how a radical innovation can cause major changes in the market. The model used in this thesis has followed the route of complementarity versus substitutability. The theory states that older, incumbent companies often fail at the onslaught of new disruptive technologies. One of the reasons for not being able to succeed with the new wave of innovation is that they were unable to compete with the much lower profit margins that the new smaller companies operated on; and not due to lack of technical knowledge or lack of money. Disruptive technologies are usually lower in performance compared to the original technology and are considered either low-end disruptions or new market disruptions. Low-end disruptions are those targeted at users who have been by-passed or overlooked by previous technologies that were too expensive or sophisticated. New market disruptions are those targeted at new customers who were not previously served by the older product.

As described in Chapter 2 of the thesis, new technologies are said to be either radical or incremental in nature. Radical new technologies are innovative in nature, that is to say, they introduce something new (Christensen 1997). Incremental technologies on the other hand, are technologies which have their roots in the previous technology or are based on something not entirely new. It is often viewed as a step up from the originating technology.

Christensen's analysis of the firm's dilemma in its view of disruptive technologies is one that follows from Schumpeterian economics and Rosenberg's theory (Christensen 1997) (Rosenberg 1982). From the macro economic analysis done by Schumpeter, Christensen's analysis presents a micro-management outlook where he looks at an individual firm's response to a disruptive technology. A new model which incorporates the concepts of complementarity and substitutability has been introduced in this thesis. It works on the assumption that there was a missing link between when an incremental or radical technology was introduced to how it disrupts or sustains a market. The complementarity and substitutability concept fills this void by introducing the possibility that firms that react that react to a new disruptive technology in different ways will result in the technology having a different type of impact in the market.

Complementary technologies are ones that are work with the current technologies already in the market. These are technologies that fill the gaps that the current technologies are not able to and they work in harmony with these current technologies. Substitute technologies are those that present a threat to current technologies and work as alternatives to the current technologies. They are able to replace current technology and thereby possibly leading to a market disruption.

Substitute technologies are therefore more likely to result in a disruptive market change. However, substitute technologies may also lead to sustaining market changes. An example of such a technology is WiFi. WiFi was first publicised as being a potentially disruptive technology to mainstream mobile technologies. Mobile technologies are characterised by their wide coverage and mobility. WiFi was not able to match mobile technologies in these criteria; however, in the speed criteria, WiFi has a huge advantage over mobile technologies. However, mobile operators and WiFi operators alike adopted WiFi as a complementary product and have been deployed by mobile operators as part of their suite of services- catering. WiFi hotspots have been deployed in places (such as airports and cafes) where people have waiting time or time to spare which they could use by accessing the Internet with a laptop or WiFi enabled device.

On the other hand, when we look at the development work that is going on with the 802.11 standard now (such as the 802.11n and 802.11s), future revisions will make WiFi more substitutable to mainstream technologies. When these revisions come into practice, it would make WiFi more mobile and thereby competing on the same performance criteria as mobile technologies. Today WiFi is at a crossroads. It is a complementary product to mainstream mobile technologies but WiFi is one complementary product that could potentially lead to a disruptive change in the market. With this, the earlier assumption that complements will only lead to sustaining market changes had to be changed as the possibility of a complementary technology leading to a disruptive market change is also probable. This is represented in Figure 40, which is an edited version of Figure 13 from Chapter 2. It shows that radical innovations may become substitutes or complements and both substitutes and complements both have the possibility of becoming either a market disruption or to sustain the market in its original technological path. It is of course difficult to predict which of these paths a particular technology will take. And a lot of this depends on strategies of companies that actually work with these technologies and their adoption strategies to new technologies.

There are different factors that contribute to technological changes and innovations. At the start of this project, the two main factors of technology and business were considered. However, it soon became obvious that these two factors were not the only major ones contributing to technological changes. One apparent factor that was initially not considered was that of standardisation and the standardisation community. As the project progressed, it was realised that it would not be possible to hold a substantial discussion without looking into the role played by standardisation.

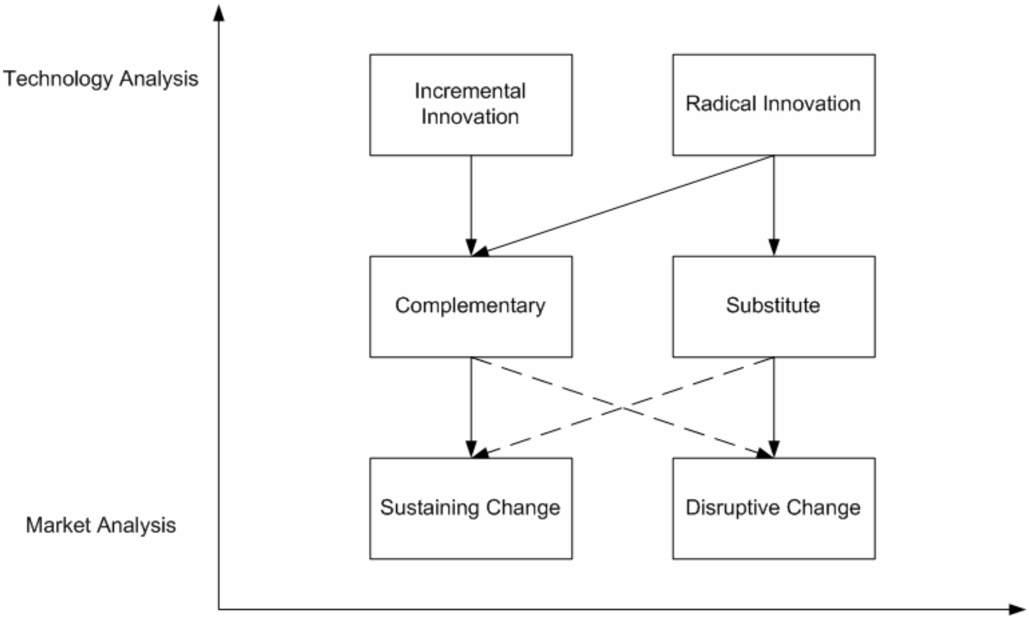

Figure 40. Relationships between innovation, complementarity, substitutability and market changes.

Figure 41 shows how technology, business and standardisation contribute to technological change. The innovation is seen as the first implementation of the invention or in this case, the technology in question. So we see that technology, business and standardisation are contributing factors to the innovation. Diffusion occurs when the technology or innovation is disseminated and distributed to users through sales and marketing techniques. When users have had the chance to experience the new technology or product, critical feedback through different channels from users back to the companies distributing the product or technology may result changes in any of the factors that go into the initial design and development phase of the cycle. Learning from users and making use of feedback to improve the specifications of the product should be part of the feedback process.

Technology, Business and Standardisation would affect the direction of technological change. Technology is the building block of invention. But it is only together with other important inputs that a technological invention is able to develop further and become sustainable in the market. Different contributing factors that have, to a certain degree, a deciding impact on the path technology will determine the scale and impact of the invention.

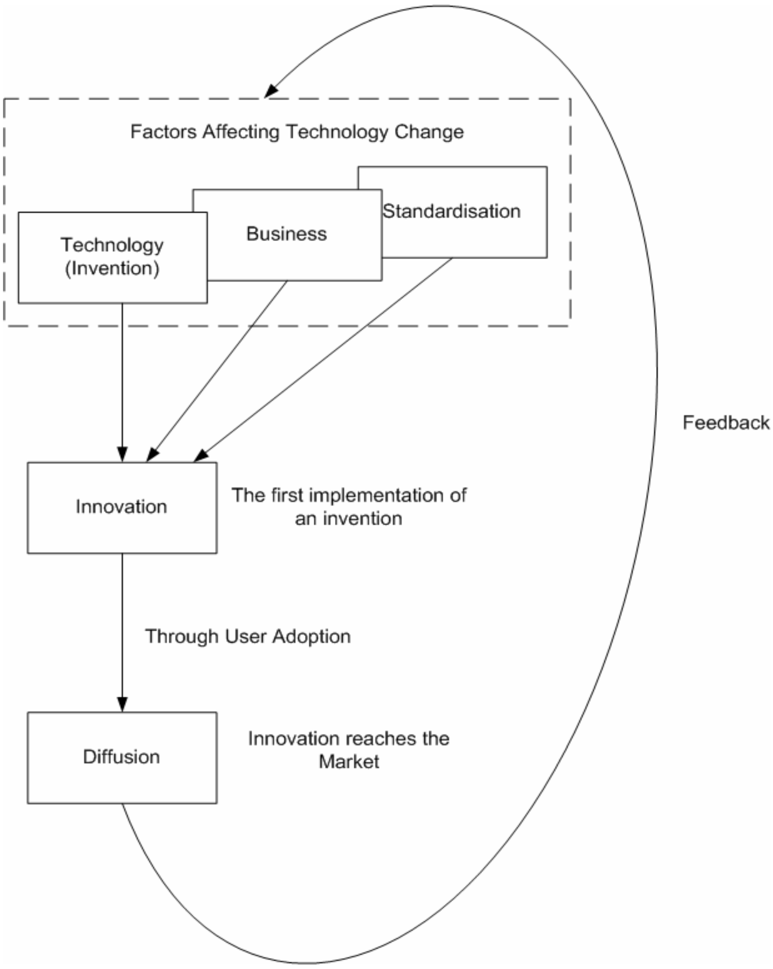

Figure 41. Technology change process

Schumpeter classified the process whereby a new, superior technology enters the market place into a trilogy of invention, innovation and diffusion. The succinct difference between invention and innovation is that invention represents the first and earliest development of a technically new product, while innovation refers to the availability of the product on the market. Diffusion is dissemination and is the process that sees the product being widely available to users when they adopt the product.

This is shown in Figure 42. Figure 42 also shows a mapping of each of these into more contemporary terms and ones which have been discussed in this thesis.

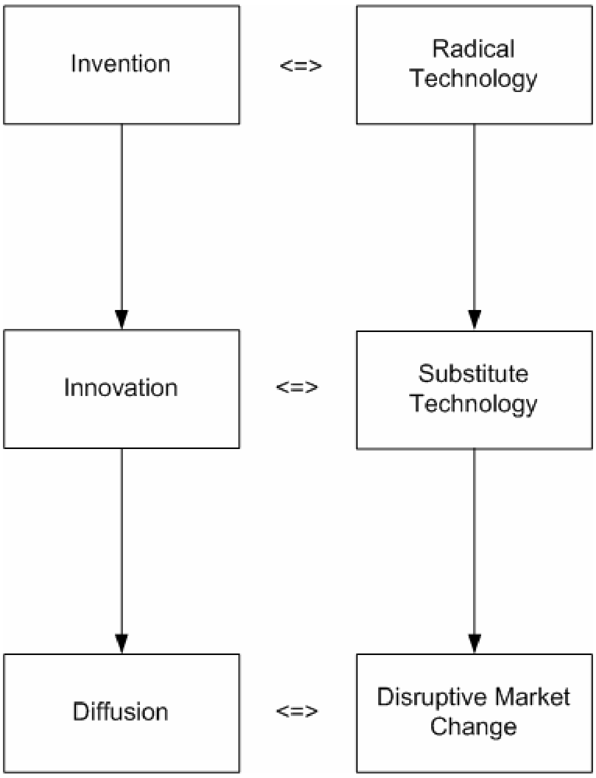

Figure 42. Schumpeter's trilogy of Invention-Innovation-Diffusion and a possible mapping

This trilogy and definition, however, is representative of a linear process. It gives the suggestion that a technological change goes from invention to innovation and finally to diffusion in a one dimensional context. This is certainly not true, especially when talking about technological changes in today's wireless and mobile market. Work on technological change by Abernathy and Utterback (Utterback and Abernathy 1975), Tushman and Anderson (Anderson and Tushman 1991), and others have shown the cyclical nature of technological changes and that the end of one technology precedes a newer radical technology or an improvement or incremental change to the existing technology (OECD and IEA Information Paper 2003). This thesis has shown this to be true and that the process is neither a simple nor a linear one and that to get from invention to diffusion, different complex processes take place and different factors interact with one another in the creation of a new product.

Technical change is a multi-dimensional process and it is seen as interplay between many different factors. This thesis has shown the triple input of technology, business and standards have a part to play in the way a new technology develops. The contribution of technological development, market and business issues and standardisation[144] determine the direction of a new technology. Although there is no guarantee that a new technology will become disruptive to the market (as it could also lead to a sustaining change), the amount of disruptiveness could be jointly dependent on the factors mentioned but also on the strategy of individual firms in their view of the particular new technology and how it fits into their current position in the market.

Technological development and markets are undeniably connected and there is a constant feedback process from the users in the market to give indications to further technical improvements in a particular product. This feedback process, together with standardisation, could be seen to create path dependence and lock in to a particular product (Arthur 1989). Technological evolution paths depend on the original conditions that it was subject to, and whichever technology is chosen in the early phase of the technological path will lead to path dependence and subsequent lock in of users to this technology. Standardisation too has a part to play here because technology often has to go through a process of standardisation before it is marketed and once a standard is adopted by the masses, it will be difficult to dislodge. Figure 43 shows the process of technological change or the cycle of technology to market and how business strategy and business models contribute to the processes.

[144] The author acknowledges that other factors affecting technology change or evolution exist but that the three mentioned in this thesis play significantly important roles.

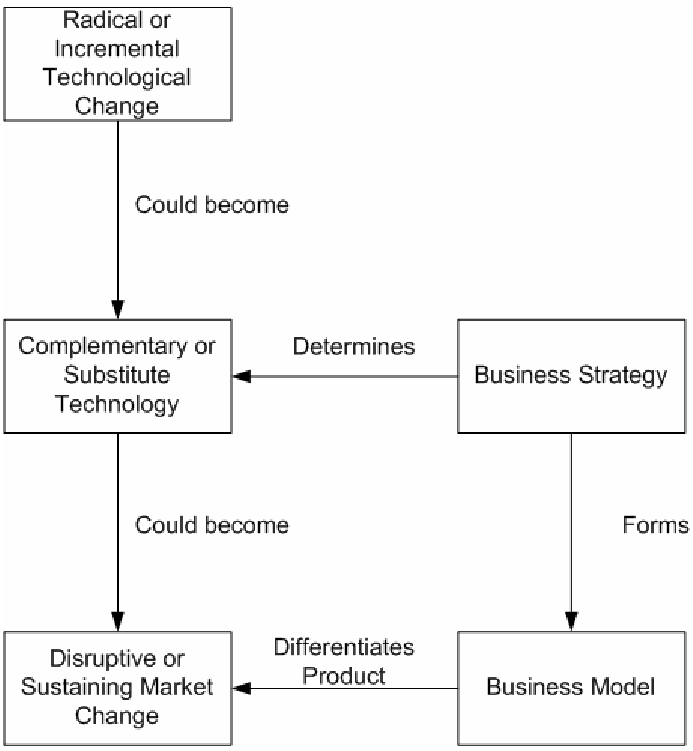

Figure 43. Relationship between technology and market.

There are different organisations where standards are developed. These range from international standards development organisations such as the ITU to industry based alliances such as MIPI. Standardisation within the mobile and wireless community has been growing in importance, mainly due to the number of technologies and choices available in the industry. There are several advantages to standardisation:

1) Choice of manufacturers and suppliers to choose from
2) Economies of scale
3) Exchange of knowledge between partners
4) Interoperability of components and parts

Unfortunately, standardisation does not come without disadvantages. One of the possible outcome of standardisation and its processes is that it could lead to the stifling of innovation and innovativeness in developers. Working on standardised parts and interfaces means that developers are obliged to work within the scheme of the standardisation committee. This reduces the chance of developing something radical, which could result in new and better technologies. Standards development organisations are also likely to work towards complementary products to existing ones. This thus reduces the possibility of substitute products that are more likely to become disruptive in the market.

When a radically new technology becomes a reality, it will probably have a stronger chance of being a substitute technology by companies than a technology that is incremental in nature with respect to the existing technology. It is therefore, more probable that the substitute technology would therefore become a market disruption. However, on the road from being a technological breakthrough to a market disruption, the adoption of the technology by companies in the industry would play a vital part in its development. Companies have strategic choices when it comes to new technological innovations. On one hand, they may adopt the technology as a complementary and therefore one that will work with their current products. This paves the way for the technology to become a sustaining market change. On the other hand, companies may adopt view the technology as a threat, and therefore a possible substitute to their current products. This stance then paves the way for the technology becoming a market disruption. Therefore, companies either see the complementarity of the technology or the threat and thereby substitutability of a product with relation to their current technologies or products. These differences are guided by the strategies laid out by individual companies. Business models, which are representations of strategy, will then help to determine the success or failure of the technology.

9.2 Technology Change Factors

The multitude of technologies that exist in the mobile and wireless industry today is not without its own sets of problems and issues. It is difficult to develop one technology on its own and not consider others around it. Incremental and radical technological changes alike require that different technologies are able to work together in heterogeneous environment. True heterogeneity is not an easy goal to attain. It requires much hard work in research and development into technology as well as business opportunities and good standardisation practices. Joint contribution from technical inputs, business considerations and standardisation are important for technologies to move forward.

Incremental changes are small changes based on existing technologies. Radical changes, on the other hand, occur when a novel technology is introduced. These two types of technological changes are characterised in many different industries and play an integral part in the development of products and processes. Incremental changes occur with greater intensity compared to radical changes, due to the nature of the changes themselves. However, it remains that many different factors decide the fate of both incremental and radical technological innovations.

Technological considerations are the building blocks of technological changes. Several important factors to think about include:

1) Speed
2) Content
3) Network security
4) Personal Privacy and security
5) Handoffs, handovers and QoS
6) Devices

As different access technologies come together in a heterogeneous environment, each of the points above will play essential roles in its development. Networks must be secure to use and must be well integrated with services and applications. Different networks must be interconnected and interoperable with one another to provide seamless roaming for users with similar quality of service throughout. Available mobile devices too must be able to work seamlessly with different networks and to let users interface easily with different services, applications and content.

Business considerations are important contributions to technology evolution or revolution. How businesses make decisions and the different aspects of business and markets play a role in the path of technology evolution. Important business considerations have been looked at such as:

1) 3G licence costs
2) Investments and sharing of resources
3) Competition leading to loss of revenue
4) Appropriation concerns in strategic alliances
5) Vendors and suppliers
6) Market cooperation
7) Coopetition

3G licence costs were something that mobile operators had to spend huge amounts of money over and this may have affected the way operators have invested in deployment and other operating costs. The high license costs have indeed made several operators engage in network sharing agreements so as to minimise 3G deployment costs. In Europe, deployment costs have been estimated to be twice the amount spent on licenses and this is why investments in other areas have had to be reassessed and sharing of resources have become important considerations. Competition will continue to be strong in the 3G arena and both mobile operators and device manufacturers will likely have to contend with loss of revenue due to lower selling prices. Because strategic alliances now play such important roles in the mobile industry, appropriation concerns have risen. The right balance between sharing of knowledge and amount of revenue appropriated from such alliances has to be struck, but this is often difficult to achieve. Vendors and suppliers have to be able to provide the industry with compatible equipment and products if a technology is to be successful. IN the earlier days of 3G, device manufacturers were blamed by operators for the slow take-up rate of 3G ser vices. Market cooperation and competition between firms in the market go hand in hand, even more so today, when alliances and partnerships play such important roles in the advancement of technology. Strategic alliances are cooperative relationships but competition amongst firms engaged within the strategic alliances is what drives the cooperation. Market cooperation is essential for knowledge sharing and social embeddedness. Competition on the other hand, is what drives innovation and is what drives companies to better one another.

Standardisation has also been found to play a key component when one looks at technology evolution and technology change. It is one of the main factors driving technological development in the mobile industry today. Different types of standards policies exist and there are undertaken in different ways. De jure standards are officiated by standards bodies that work in the development of standards as a collective group. De Facto standards are set by market mediated processes (Grindley 2000).

Standards development organisations have changed and evolved over the years, just as the technology and the market has. This represents both old and new challenges to how standards are developed and introduced. In any standards organisation, much bureaucracy exists and time is needed for agreements to be reached and development work to take place. One of the strong points of standards development organisations such as the IEEE is that it brings together different developers from different communities such as industry, governments as well as educational institutions. However, it is the effect that standardisation organisation has on potentially disruptive technologies that may make them not so conducive to the development of such technologies. Standards organisation work towards complementing older technologies with new ones. This underlying commitment already draws work towards complementarity of products rather than substitutability.

9.3 Relationship between Business Models and Business Strategies

Business strategies and business models are huge contributing factors to the success of companies in the mobile industry today. Differences between business models and business strategies but how they are also related. (Porter 1996) (Porter 2001) says that strategy defines “a company’s long-term position in the marking place, making the hard trade-offs about what the company will and will not do to provide value to customers”. Business models are the abstract representation of business strategies and provide a description of the inter-relationships and processes that occur between the different parties in the value chain.

Business models based on Faber et al’s paper were developed for both the mobile operator and the device manufacturer.

In the thesis, both business models and business strategies have been analysed and their differences explained. Both business models and business strategies for the mobile operator and the device manufacturer have been developed. These have been developed in relation to PNs which are of interest to both parties. PNs present new opportunities and new prospects for both the mobile operator and the device manufacturer. However, these opportunities will not be without threats which they both will have to confront and adopt their strategies and business models to. PNs will be a thing of the future, because it encompasses the concept of heterogeneity as well as personalised services for industry specific groups. They present not only technological challenges but also business and social challenges that will have to be undertaken by all members of the value chain.

As seen from Figure 42, radical and incremental technologies will remain outside the main business arena until they are addressed by companies and adapted either as complementary or as a substitute to current mainstream technologies that these companies are developing and marketing. When companies have decided on their attitude towards new potentially disrupting technologies, they will develop and apply these strategies to the market. These technologies will then contribute to the market as being either sustaining changes or disruptive changes. Business models and the different design domains that exist in business models as characterised by Faber et al are probably what is going to differentiate them from other competing technologies (Faber et al 2003).

9.4 Revisiting the Questions Asked Earlier…

The research questions that were formulated in the beginning may now be answered based on the information collected in this thesis.

Q1. The theory of disruptive technology will be used as a basis of analyses of how newer technologies may prove to ‘invade’ the space of current technologies. How will potential disruptive technologies change the path of mobile technology evolution?

Mobile technologies today cover different types of air interfaces; from second generation technologies such as GSM and CDMA to third generation technologies like WCDMA and CDMA2000 EV. Newer potential disruptive technologies include WiMAX and evolved WiFi, which could become competing technologies to conventional mobile technologies in the future. All these different standards will exist in a segmented global market. It has since been established that the disruptiveness of technologies will come only in the market. The amount of disruptiveness will therefore depend on the business strategy adopted by each company and this will in turn determine the substitutability or complementarity of the technology. Once this is determined, then only will can disruptiveness or sustainability with relation to the market be established. Potential disruptive technologies can change the path of mobile technology but the amount of change that occurs depends not only on its technical merits but also on its business merits and of standardisation. Technologies that are radical and potentially disruptive may in effect turn out to be sustaining market changes if industry so chooses to adopt it as a complementary technology. Potential disruptive technologies may present themselves as possible competitors to current technology platforms. However, as the industry today is one that is looking for complementing technologies, it may not be so easy for newer technologies to truly disrupt the market. Disruptive technologies imply therefore, that the industry has already decided and have strategies to cope with these market disruptions. For that reason, technologies such as WiMAX and evolved WiFi have the potential of shifting the industry from one that is a purely mobile industry towards one that includes ubiquitous and seamless mobile and wireless technology convergence.

Q2. Different networks are now being interconnected. To achieve a truly ubiquitous and heterogeneous network, different types of networks will have to be interconnected and interoperable. How important is seamless roaming and availability of services?

Interconnectivity plays an important role in the next phase of the mobile industry. It is, however, difficult to achieve full interconnectivity and seamless roaming between networks as different parameters and issues have to be considered. This thesis has looked at several ways that interconnectivity may take place between GSM and UMTS network and also between WLAN and UMTS networks. Those methods mentioned here rely on different degrees of coupling between the networks. Inter-connectivity therefore takes place at the network level. New novel methods of achieving seamless roaming between networks are also being developed that require almost no coupling between networks. Techniques such as software defined radio will redefine the way interconnectivity is done. With such techniques, there is no need for networks to be interconnected. Roaming between networks will be defined by the mobile terminals which will be able to adapt to different air interfaces. Charging and other interoperation criteria will have to be sorted out as the technology progresses. True seamlessness will mean that the user does not have to be aware when a session switches from one network to another. All personalised preferences will have been initially specified so that the user is able to get the type of services he wants and when he wants it. One of the strategies that mobile operators are adopting is that of coverage between different types of networks to provide a heterogeneous network to users. True heterogeneity is not just about having networks interconnected; it is also about being able to use services seamlessly and with ease. This will only be attainable when different entities in the value chain work together for this purpose. A balance amongst technological, economic factors, standardisation and other related issues will have to be reached in order for the vision of a heterogeneous network to be achieved.

Q3. Different technologies and companies will have different goals and thus different business models. How will the business models of entities such as the mobile operator and device manufacturer evolve to changes in technology and implementation?

New business models will have to be developed in relation to new technologies. New business models will also have to be developed in relation to old technologies in a new type of market. As we see today, the main entity in the value chain is that of the mobile operator. This is mainly due to the market it commands and its share in the business. The mobile device manufacturer has always played an important role in the value chain by providing devices to the network operator who then sells them to users. As the industry continues to develop, and as the advent of new wireless technology looms nearer and nearer, the mobile operator will have to find ways of either incorporating the new technologies into their present suite of services or to find means of protecting their market. At the same time, the device manufacturer will find new ways of reaching the users, through new wireless operators and also through different sales outlets. As the industry moves forward, one of the possible scenarios is that of Personal Networks. Personal Networks will require both new business strategies and business models. The differences between business strategies and business models have been explored in Chapters 7 and 8. Business strategies will probably have to be flexible in adapting to new technologies and a new environment while new business models will have to be developed in order to address new markets. As technology changes and the market changes, there will be a need to re-look business strategies and business models. Technology changes leads to changes in business and therefore requires new strategies and models with which to succeed with. Therefore, business strategies and business models must be dynamic and able to change and adapt to new potentially disruptive technologies.

9.5 Last Words

The difficulty in analysing a potential disruptive technology is just that; it is not something that is already in the market and neither has it got a history to compare with. It is therefore open to speculation as to what new technology will really become a market disruption. A potential disruptive technology could be any one of the multitude of new mobile and wireless technologies out there. Disruptions can also occur at different levels and not limited to the whole product. In this thesis, it has been explored that from radical technology to market disruption, there must be another plane of analysis that pushes the radical technology in the direction of market disruption. This plane of analysis is one of complementarity or substitutability. Companies decide, based on their business strategies, how a new radical technology is going to be adopted. If the technology is viewed as a substitute, it is more likely to create a market disruption that if the technology were adopted as a complement into the present suite of services of the company in question.

As the ICT industry moves into its next phase, research and development of whole new concepts have very much been a part of the European Commission's work on the telecommunications for the future. As described earlier, one such project that has contributed to new ideas for the future of mobile communications is that of MAGNET. It envisions the future in terms of Personal Networks where ubiquity and personalisation is part of the entirety of communications of the future. In the PN environment, new market players will surely enter with new products. At the same time, older established market players such as the mobile operator and the device manufacturer will have to find new positions in this new market. If they are going to keep the revenues that they have in today's mobile market, they will have to adapt to the PN environment with new services and programs. New developments in the industry mean both opportunities and threats to older market players. Business strategies and business models will have to change in order to address the new technological developments as well as market changes. The development of concepts such as PNs and how they could lead to changes in the market will be important things to consider in the future.

In the years to come, heterogeneous network could become connected with the concept of PNs. This environment is described as one with different types of network accesses, with seamless roaming between networks and simplicity of use. It is also likely to be industry specific, addressing the needs of different sets of users. This means that industry specific services will be needed to address different industries. Because of this cross industry convergence, new partnerships and relationships will be formed to address the new requirements.

Different technical and economic factors affect the development of the technology. However, with new technologies, standardisation and the processes involved in standardisation will also play an increasingly important role. With different technologies and services needing to work together, interconnectivity and interoperability as well as standardised parts and interfaces will more likely to be needed. Therefore, the interplay amongst technology factors, economic factors as well as standardisation is one that will bring the mobile and wireless industry forward.

Therefore, to summarise, this thesis has investigated the different aspects of disruptive technologies and how certain factors may affect the future of the ICT industry. To sum up, the thesis has studied:

1) The relationship between innovation trilogy and technology disruption trilogy
2) how radical technologies may become market disruptions
3) how technological factors, economic factors as well as standardisation play important roles in determining the path taken by a technology how business strategies determine the path of radical and incremental technologies
4) how business models are used to address different market needs

There exist many different paths for radical technological breakthroughs to take. As we have seen with the example of WiFi, what began as a potentially disruptive change based on a radical technology has become something quite different in recent years, WiFi is now a complementary product to main stream mobile technologies and has been adopted by mobile operators as a product that provides complementary services to their mobile products. As WiFi continues to develop (with new amendments to the earlier standards where past weaknesses are addressed), it represents the possibility that the technology could become in fact a substitute to main stream mobile technologies.

Although different paths are available to new radical technologies, the extent to which these new technologies will be able to break into the market very much depends on individual companies' adoption strategies of these new technologies. Because of the way standardisation works and the way the industry has been built up on large amounts of investment to present day technology, it may lead to the fact that radical new technologies will not get into the market as substitutes. In general, the industry is likely to be keener on complementary products as compared to substitutes. This can mean that radical technologies and innovativeness may not be rewarded as much as incremental technologies and conformity. The business strategies and business models of companies therefore are important in determining the disruptiveness or sustainability of a technology and the path of technology changes to come.

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Appendix 1- List of Publications

Conference and Journal Publications

"New mobile systems and services in Europe, Japan and South Korea", The Stockholm Mobility Roundtable 2003, Stockholm, Sweden, May 2003, A. Henten, H. Olesen, D. Saugstrup, **S. Tan**.

"Mobile Communications: Europe, Japan and South Korea in a Comparative Perspective", Special issue of INFO Journal, June 2004, A. Henten, H, Olesen, D. Saugstrup, **S. Tan**.

"UMTS vs. WLAN- The European Scene", World Wireless Congress 2004, San Francisco, USA, May 2004, **S. Tan**, D. Saugstrup, H. Olesen.

"3G- An Unnecessary Step Forward?", Communications in the 21^{st} Century Conference 2004, Budapest, Hungary, June 2004, **S. Tan**.

"Mobile Health: Personalisation of Health Care Assistance Services", Tromsø TeleMedicine and e-Health Conference, Tromsø, Norway, June 2004. S. Thongthammachart, **S. Tan**.

"Mobile and Broadcast- Convergence of Technology and New Business Models", Wireless Personal Multimedia Communications Conference, Albano Terma, Italy, September 2004, **S. Tan**.

"New Wireless Technologies- Continuity and/or Change", Hong Kong Mobility Roundtable, Hong Kong, June 2005, **S. Tan**. , A. Henten.

"A Discussion of Standardisation in Relation to Disruptive Technologies", Wireless Personal Multimedia Communications Conference, Aalborg, Denmark, September 2005, **S. Tan**, A. Henten.

"WiMAX- Prospects and New Business Models", IEE 3G and Beyond Conference 2005, London, UK, November 2005, **S. Tan**.

Other Publications

"Evolution of Mobile Technology and Business Models", CTI Working Papers, Technical University of Denmark, Copenhagen, Denmark, February 2005, **S. Tan**.

“Forecasting Economic Aspects of Future Wireless Services”, IST project NEXWAY deliverable, November 2003, M. Falch, A. Henten, D. Saugstrup, K.E. Skouby, R. Tadayoni, **S. Tan**.

“Draft Socio-Economic Impact and Business Models for PNs”, IST project MAGNET deliverable, November 2004, K. Alm, M. Björksten, S. Dixit, A. Henten, A. Hoikkanen, B. Jiang, V. Kaldanis, R. Prasad, R. Roswall, D. Saugstrup, **S.E. Tan**, J.P. Vila.

“WLAN versus UMTS: a Cene Européia, RTI – Redes, Telecom e Instalações, Ano VI N° 65, Outubro, 2005, Brazil, **S. Tan**, D, Saugstrup, H. Olesen.

“Socio-Economic Impact and Business Models for PNs”, IST project MAGNET final deliverable, December 2005, M. Björksten, S. Dixit, A. Henten, A. Hoikkanen, B. Jiang, V. Kaldanis, R. Prasad, R. Roswall, D. Saugstrup, **S.E. Tan**, J.P. Vila.

Appendix 2- List of Individuals Interviewed

1)	Mikko A. Uusitalo	Nokia, Espoo, Finland
2)	Peter Toft	Nokia, Copenhagen, Denmark
3)	Ari Jaaksi	Nokia, Tampere, Finland
4)	Risto Savolainen	Nokia, Salo, Finland
5)	Paul Melin	Nokia, Espoo, Finland
6)	Rune Roswall	TeliaSonera, Malmö, Sweden

Appendix 3- Co-Author Statements

Co-author Statement

Co-Author Statement describing the authors' contribution to the report for Nokia:

"Disruptive Technologies and Other Issues Facing the Mobile Industry Today"

Jointly written by Su-En Tan and Marie Louise Havbo-Kaalund

With regards to the chapter mentioned above, I hereby declare that my contribution to this report has been limited to the following:

- Discussion of ideas
- Jointly conducting interviews and discussions with different individuals
- Contribution in the formulation of text (approximately 20-30 %)

Copenhagen, Denmark, 3rd February 2006

Marie Louise Havbo-Kaalund
Stud. Ha.Kom

Appendix 3

Co-author Statement

Co-Author Statement describing the authors' contribution to Chapter 3 (PAN/PN Business Models and Strategies) of:

"IST-MAGNET Project Deliverable D1.4.1b (Socio-economic Impact and Business Models for PNs)"

Jointly written by Su-En Tan and Rune Roswall.

With regards to the chapter mentioned above, I hereby declare that my contribution to this chapter has been limited to the following:

- Discussion and presentation of ideas.
- Input from the Operator's point of view.
- Contribution in the formulation of text (approximately 20-30 %).

Malmö, Sweden, 3rd February 2006

Rune Roswall

Rune Rosswall
TeliaSonera, Sweden

Appendix 3

Co-author Statement

Co-Author Statement describing the authors' contribution to the paper:

"New Wireless Technologies: Continuity and/or Change"

Jointly written by Su-En Tan and Anders Henten

With regards to the chapter mentioned above, I hereby declare that my contribution to this chapter has been limited to the following:

- Discussion of ideas and theories
- Contribution in the formulation of text (approximately 5-10 %)

Kgs. Lyngby, Denmark, 3rd February 2006

Anders Henten
Associate Professor
Center for Information and Communication Technologies
Technical University of Denmark

CICT Ph.D Series:

CTI/CICT Ph.D Series (from 01.05.2005 the series changed title to CICT PhD Series).

Nicolajsen, H. Westh (2005). Tilpasning af groupware i organisationer - betydningen af metastrukturering. Kongens Lyngby: Technical University of Denmark, Center for Information and Communication Technologies (CICT). (CICT PhD series, no. 7). 253 p. ISBN 87-90288-23-8.

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